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NATIONAL DAM INSPECTION PROGRAM. MORAINE STATE PARK DAM (NDI PA--ETC(U)
SEP 78 DACW31-78-C-0052
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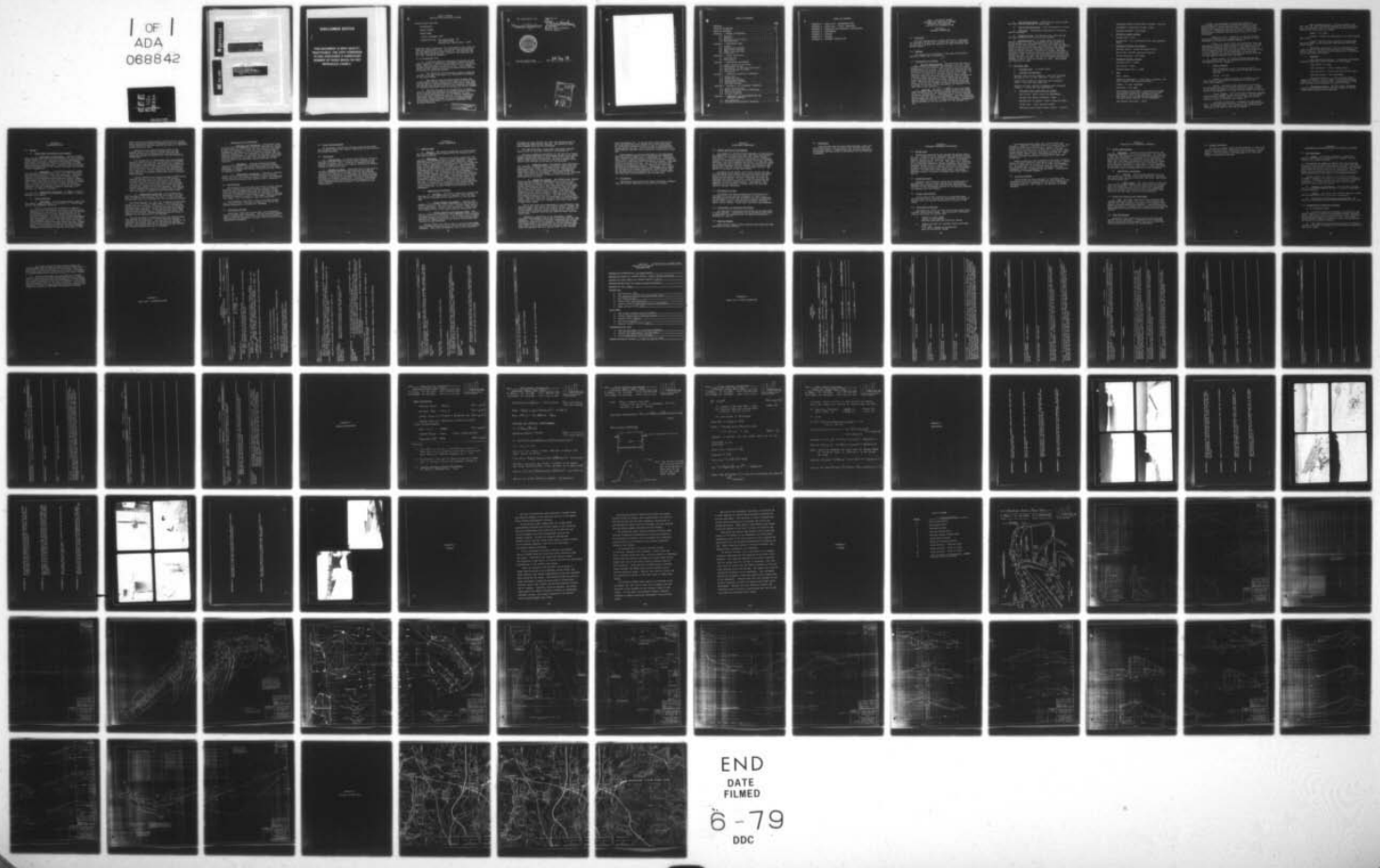

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National Dam Inspection Program. Moraine State Park Dam (NDI PA-273), Ohio River Basin, Muddy Creek, Butler County, Pennsylvania. Phase I Inspection Report.

Contract No. DACW31-78-C-0052

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PHASE I REPORT
National Dam Inspection Program

Moraine State Park Dam

Pennsylvania

Butler County

Muddy Creek

1 and 5 September 1978

Inspection Team - GAI Consultants, Inc.
570 Beatty Road
Monroeville, Pennsylvania 15146

Based on visual inspection, past performance, and review of available engineering data, the dam and its appurtenances are considered to be in good condition. The spillway can pass the flow resulting from a storm of PMF magnitude and is, thus, considered adequate.

It is recommended that:

a. A warning system be developed to provide for the safe evacuation of downstream inhabitants should the need arise. This plan could be incorporated into the "Operation and Maintenance Manual" currently in use. This program should include round-the-clock surveillance during periods of intense or prolonged rainfall.

b. The "Operation and Maintenance Manual" should be revised to include a procedure for installing the stoplog of the outlet works.

c. The manhole which provides access between the outlet chamber and the control room should be secured with a slide bolt or locking mechanism on the control room side. The control room and gate controls are currently accessible to unauthorized persons entering through the outlet chamber.

d. The dam continue to be inspected on an annual basis to detect any hazardous conditions which may develop. It is further suggested that the piezometers be read during the annual inspection and the results compared to the latest data reviewed by Ralph B. Peck and Associates. Significant deviations from the latest readings should be evaluated with respect to effects on embankment and spillway stability.

GAI Consultants, Inc.

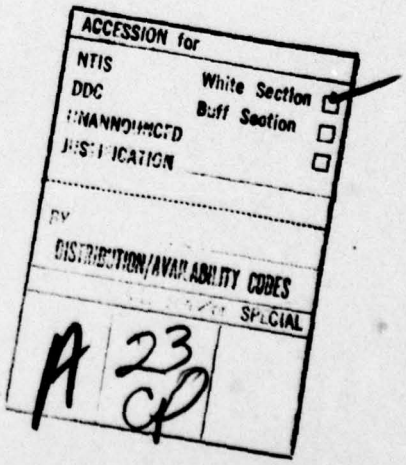
Bernard M. Mihalcin, P.E.

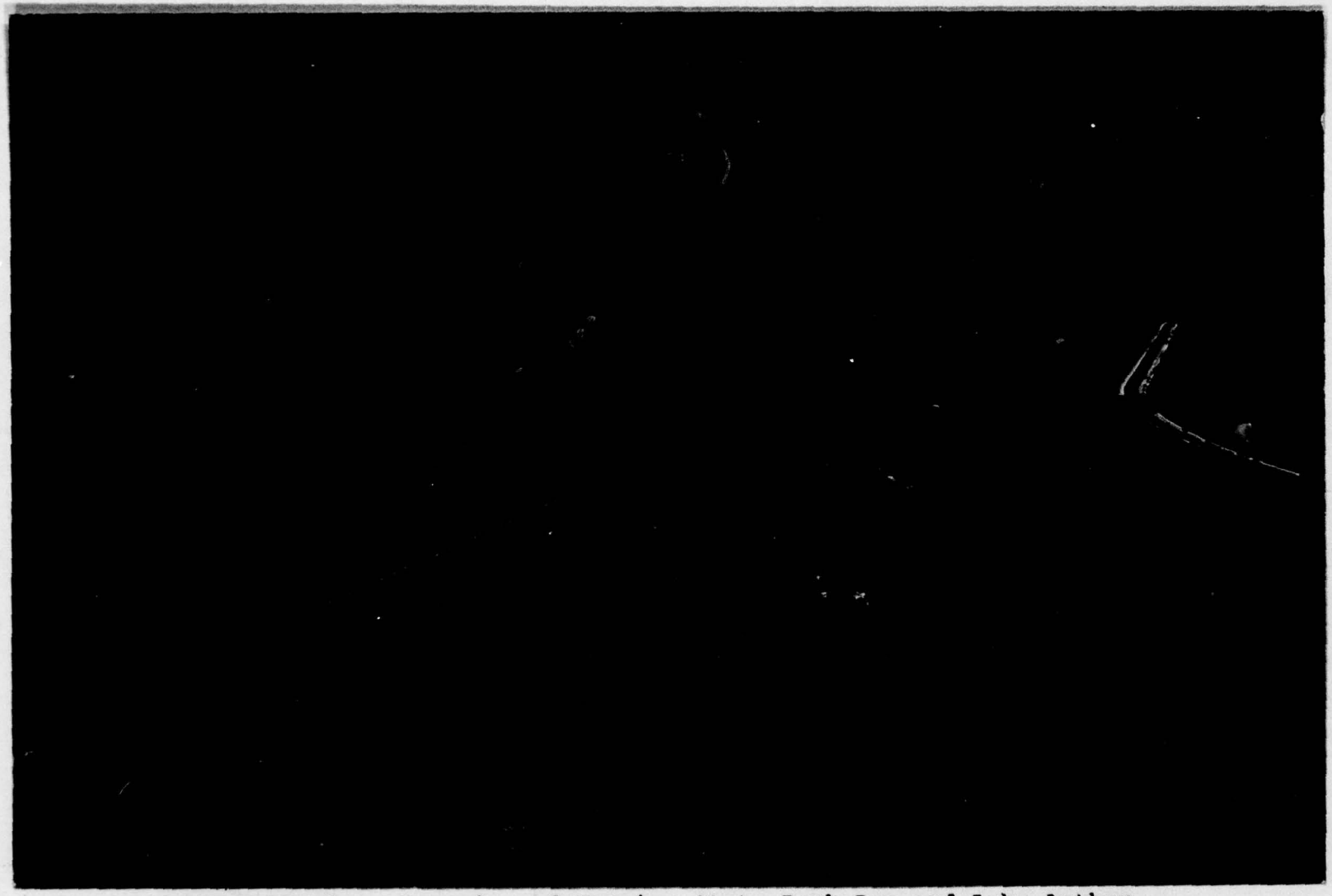
Date 26 Sept 78

Approved by:

G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

Date 28 Sep 78





PHOTOGRAPH 1A - Overview of Moraine State Park Dam and Lake Arthur.

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
MORAINE STATE PARK DAM
NDI# PA-273, PENNDER# 10-68

SECTION 1
GENERAL INFORMATION

1.0 Authority.

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

1.1 Purpose.

The purpose is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Moraine State Park Dam is a zoned earthfill embankment approximately 1,933 feet long, including a 60-foot concrete ogee spillway section, with a maximum height of 55 feet. The facility is serviced with an uncontrolled ogee-crested concrete spillway discharging into a concrete stilling basin 60 feet wide and 52 feet long. In addition, the facility is equipped with an outlet works located through the concrete ogee spillway which consists of a 72-inch sluice gate and a 12-inch bypass pipe for downstream low flow augmentation without operating the sluice gate. Operation of the sluice gate and bypass piping and access to the Outlet Chamber is from the control building situated on the crest of the embankment and adjacent to the east side of the spillway.

b. Location. The dam is located in Worth and Muddy Creek Township, Butler County, on Muddy Creek, three miles north of Portersville and approximately fourteen miles west of Butler, Pennsylvania. Interstate Route 79 lies approximately 3,500 feet west of the embankment. The dam, reservoir, and watershed are contained within the Prospect, Portersville, and Mt. Chestnut U.S.G.S. 7.5 minute Pennsylvania quadrangles. The coordinates of the dam are N40° 57' 45" and W80° 07' 20".

c. Size Classification. Large (55 feet high, 98,000 acre-feet storage capacity at top of dam).

d. Hazard Classification. High (see Section 3.1.c.5).

e. Ownership. Pennsylvania Department of Environmental Resources.

f. Purpose of Dam. The Moraine State Park Dam was designed primarily for recretational purposes.

g. Historical Data. In August 1962, the firm of Michael Baker Jr., Inc., was engaged for the purpose of making studies and investigations that would lead to the design of the dam structure. On August 16, 1965, the General State Authority and the Department of Forests and Waters filed an application with the Water and Power Resources Board to obtain a permit to construct the dam. The Water and Power Resources Board issued the construction permit on October 5, 1965. Bids for the construction of the dam were opened September 30, 1965, and the construction contract was awarded to the low bidder, The John G. Ruhlin Construction Company of Akron, Ohio, on October 21, 1965. The project was completed in 1968.

1.3 Pertinent Data.

a. Drainage Area. 53 square miles

b. Discharge at Dam Site.

Maximum known flood at damsite - Flow over spillway measured to be 1.9 feet (620 cfs) - June, 1977.

Outlet works conduit at operating pool elevation (1190) ≈ 1130 cfs (see Figure 3).

Ungated spillway capacity at maximum pool elevation (1204.5) ≈ 13,000 cfs (see Appendix C).

c. Elevation (feet above mean sea level).

Top of Dam - 1204.5 (crest of embankment).

Maximum Pool Design Surcharge - None.

Maximum Pool of Record - 1191.9 (June 26, 1972).

Normal Pool - 1190 (spillway crest).

Upstream Portal Invert Outlet Conduit ≈ 1158.92.

Downstream Portal Invert Outlet Conduit ≈ 1157.29.

Streambed at Centerline of Dam ≈ 1155.

Maximum Tailwater - Not known.

d. Reservoir Length (miles).

Maximum Pool ≈ 20.5.

Normal Pool ≈ 17.5 (elevation 1190, ogee spillway crest).

e. Reservoir Storage (acre-feet).

Spillway Crest ≈ 38,000 (elevation 1190).

Top of Dam ≈ 98,000 (elevation 1204.5).

Design Surcharge - Not known.

f. Reservoir Surface (acres).

Spillway Crest ≈ 3,200.

Top of Dam ≈ 4,800.

Maximum Design Pool ≈ 4,800.

g. Dam.

Type - Earth.

Length of embankment - 1,933 feet, including a 60-foot concrete ogee spillway section.

Height - 55 feet (maximum).

Top Width - 22.5 feet.

Side Slopes (Downstream) - Generally 2H:1V with the following exception: Between Station 8+00 and Station 11+90 on the downstream slope a berm with a 10H:1v slope has been provided at the approximate midpoint of the embankment.

Side Slopes (Upstream) - 3H:1V.

Zoning - the embankment contains an impervious core encased both upstream and downstream within a thick pervious shell. On the upstream side, a sloping filter blanket lies between the pervious shell and riprap slope protection. Downstream the pervious shell is underlain by a blanket drain extending from the core to the toe of the embankment.

Impervious Core - Figures 8, 9, and 10 indicate the central portion of the embankment is composed of clays compacted to 100 percent Standard Proctor.

Cutoff - A cutoff trench was constructed along the embankment centerline from Station 3+00 to Station 11+75 and from Station 16+50 to Station 19+50. Additional cutoff is provided by Wakefield Sheet Piling installed from Station 3+00 to Station 11+75 and from Station 16+25 to Station 20+00. In the middle portion of the embankment containing the spillway section, an impervious blanket was placed directly on rock between Stations 11+75 and 16+25.

G Grout Curtain - A 2-stage grouting program was also performed along the dam centerline from Station 10+00 to Station 19+50 (see Figure 7).

h. Outlet Conduits.

Type (Submerged inlet) - 72-inch reinforced concrete opening constructed through the concrete spillway.

Length - 14 feet.

Closure - Drawdown control is provided by a 72-inch diameter sluice gate controlled by a rising stem sluice gate operator.

Access - The sluice gate operator is located in the Operating Room directly above the outlet works. Access to the Operating Room is from the Control Building on the crest of the embankment via caged vertical ladder and gallery.

Outlet Chamber - The sluice gate discharges directly into the outlet chamber within the spillway. The discharge outlet to the stilling basin is a 9 by 7 feet elliptical opening in face of spillway (see Figure 6).

Regulating Facilities - Discharge is controlled via a rising stem which operates the 72-inch diameter sluice gate. A stoplog serves as an emergency gate which can be inserted at the inlet to the outlet conduit.

Type (Submerged Inlet) - 12-inch diameter cast iron pipe and valve constructed through the concrete spillway. The vertical inlet is in the 72-inch outlet conduit between the sluice gate and stoplog.

Length ≈ 12.5 feet

Closure - Control is provided by a 12-inch diameter gate valve.

Access - The gate valve control is located atop the floor stand in the Operating Room directly above the outlet works.

Regulating Facilities - Flow is regulated by the valve control in the Operating Room until pool elevation 1170 is reached. Below this pool elevation, air enters the outlet and breaks the siphon.

i. Spillway.

Type (Service/Emergency) - A concrete ogee-shaped spillway discharges into a concrete stilling basin.

Crest Width - 60 feet.

Crest Elevation - 1190.0 (Normal Pool).

Stilling Basin - 60 feet wide and 58 feet long.

Upstream Channel - Not applicable.

Downstream Channel - a 38-foot bottom width, trapezoidal shaped, outlet channel is located beyond the outlet sill of the stilling basin. The channel is lined with derrick stone throughout its 128-foot length.

j. Regulating Outlets. 88-inch square submerged intake portal equiped with trash rack located at the upstream base of the concrete spillway.

SECTION 2
ENGINEERING DATA

2.1 Design.

a. Design Data Availability and Sources.

1. Hydrology and Hydraulics. Extensive hydrologic and hydraulic studies were performed by the designers, Michael Baker Jr., Inc. Pertinent data are summarized in a brief report entitled, "Summary of Hydrological Studies, Hydraulics, and Stability Analysis," dated March 5, 1965, and available in PennDER files. Results of the studies and design are summarized on the contract drawings (see Figures 2 and 3, Appendix F).

2. Embankment. A detailed geotechnical study was performed by Michael Baker, Inc., for this project in conjunction with Ralph B. Peck and associates. Consideration for site selection is reportedly discussed in the "Report on Proposed Muddy Creek Reservoir, Butler County, Pennsylvania" by Ralph B. Peck and Don U. Deere, January 8, 1964. This report was not available from PennDER, M. Baker, Inc., or local State Park files. A brief but detailed summary of the entire project from investigation through reservoir fill-up, authored by Ralph B. Peck and H. O. Ireland, is, however, available.

3. Appurtenant Structures. A summary of spillway stability analysis is presented in the report listed in Section 2.1.a, above.

b. Design Features.

1. Embankment. The following excerpt taken from the Summary Report by Ralph B. Peck and H. O. Ireland summarizes the embankment features:

> After an investigation consisting of some 81 borings and the performance of tests to ascertain the strength of the lacustrine clays underlying the dam and the permeability and piping characteristics of the alluvial materials, the basic cross-section for the design was adopted. It consists of an earth embankment with conservative upstream and downstream slopes and a wide compacted clay core. The core rests on a clay-filled cutoff trench extending, where feasible, through the alluvial materials to contact with the lacustrine clays. In the central portion of the valley, however, the depth of the cutoff trench was restricted to that

which could be excavated without failures of the trench walls and without extensive dewatering; and the remainder of the cutoff to clay was achieved by means of a Wakefield sheet-pile cutoff wall.

Adjacent to the concrete outlet works in the deepest part of the valley, selected fill for the cutoff was carried to bedrock and a transition was developed between the selected fill and the sheet-pile cutoff wall.

The possibility of underseepage and the attendant danger of uplift of the toe and of piping from beneath the structure required the installation of a number of piezometers, some upstream, but mostly downstream from the cutoff and core. The purpose of the piezometers was to ascertain, particularly while the reservoir was still only partly filled, whether the cutoff features were effective and whether undesirable uplift pressures might develop.

During construction, several practical difficulties required alteration in the details of the design. Driving the sheet-piles for the cutoff walls proved difficult and the desired penetration of the piling into the impervious lacustrine clays could not always be assured. Blanketing of portions of the upstream slopes, particularly on the left abutment, was carried out to increase the length of seepage paths to compensate for possible imperfections in the cutoff wall.

2. Appurtenant Structures. The spillway is a concrete gravity overflow section, 60 feet wide by 38 feet high, founded on and anchored into rock. A grout curtain was provided along the upstream heel of the overflow section.

The stilling basin is a Type III structure as described in the U.S.B.R. "Design of Small Dams." The structure is fitted with chute, blocks, baffles, sills and counterforte training walls. The basin is 58 feet long and utilizes the hydraulic jump phenonema. Floods greater than the Assumption A flood (as described in "Design of Small Dams") will jump out of the basin, causing downstream erosion which is thought will be negligible by the designer.

The outlet works is contained within the concrete overflow section and consists of a 6-foot diameter opening, regulated by a sluice gate. Gate controls are located in an operating room within the mass of the concrete overflow section. An aluminum stop log is provided and kept on-site for emergency maintenance use if necessary.

c. Design Data and Procedures.

1. Hydrology and Hydraulics. The Maximum Probable Flood and the Assumption A flood as described by "Design of Small Dams" were determined for this facility and routed through the reservoir. Inflow and outflow hydrographs are presented by the designer in the contract drawings (see Figure 2, Appendix F). As indicated in the report upon the application for permit to construct the facility, the actual spillway capacity is less than that required by PennDER "C" curve because of the attendant storage potential of the reservoir.

2. Embankment. Although extensive testing (field and laboratory) are discussed in available correspondence, no actual calculations pertaining to stability, settlement or seepage are readily available from the owner's or designer's files.

3. Appurtenant Structures. Although no specific design files are available, drawdown and flow capacity curves for the 6-foot diameter outflow conduit are presented on the contract drawings (see Figures 2 and 3, Appendix F).

2.2 Construction.

Construction data available for review include contract drawings, specifications and bi-weekly progress reports (with related correspondence) from the designer's files. Available correspondence indicates the construction was monitored by personnel from PennDER's Department of Forests and Waters (Resident Engineer, Stan Kebbe), representatives of M. Baker, Inc., and Ralph B. Peck and associates.

Correspondence from owner's files indicates several site visits by Peck, Ireland, and Hendron to review and discuss construction techniques or problems.

2.3 Operations Records.

Daily pool level and rainfall data are recorded by Bureau of State Parks personnel. During reservoir filling, daily piezometer data were taken and regular evaluations made by Peck and associates to ensure that the facility was responding as designed.

2.4 Other Investigations.

No subsequent engineering related investigations have been conducted other than regular inspections of the facility by PennDER personnel.

2.5 Evaluation.

a. Availability. No calculation briefs or files are available from the Bureau of State Parks, PennDER or the designer (M. Baker, Inc.). Results of analyses are presented in summary form on the contract drawings and summary reports in available files.

b. Adequacy of Data. Sufficient data in the form of contract drawings, detailed specifications and summary reports are available to indicate that the facility was designed and constructed in conformance to modern accepted practices. Construction was monitored and reviewed by the designer and renowned consultants. Extensive instrumentation enabled careful monitoring during reservoir fill-up which indicated adequate response of the embankment and appurtenances.

SECTION 3
VISUAL INSPECTION

3.1 Observations.

a. General. The general appearance of the structure and related appurtenances suggest that the facility is in very good condition.

b. Embankment. Based on the visual inspection, the embankment is considered to be in good condition. Upstream slope protection is provided by blocky limestone riprap. The riprap is undergoing considerable spalling but, nevertheless, remains serviceable (Photograph 5). The downstream slope of the embankment and toe area are seeded with crown vetch and require little or no maintenance (Photograph 4). The dense mat of crown vetch makes direct observation of the slope impossible. Mr. Dickerson, park superintendent, reported that seepage was observed at one isolated location along the toe several years ago. The seepage was monitored on a regular basis and no remedial action was taken. No evidence of seepage could be detected at this location at the time of the inspection. On both sides of the service spillway, a riprap toe is provided for the downstream slope in the event that a large discharge would result in the creek overflowing its bank immediately downstream of the embankment.

c. Appurtenant Structures.

1. Spillway. The visual inspection revealed the spillway to be in good condition; however, flow over the ogee section precluded direct observation of the spillway face.

2. Outlet Chamber and Conduit. Complete submergence of the outlet conduit precluded the possibility of visual inspection. The sluice gate, 12-inch bypass outlet and outlet chamber, however, were accessible. These structures appear to be in very good condition (Photograph 11).

3. Control Building and Operating Room. The Control Building is located on the embankment crest adjacent the south side of the spillway. The building and the gaging equipment housed inside appear to be in good working order. The vertical ladder access to the control room gallery are likewise in good condition.

Directly below the control room, a vertical open-ended riser provides direct access to the gallery by the recording equipment. This facility appears to be in good condition,

although the floor beneath the riser and upstream wall of the Operating Room gallery was wet. The source of this minor seepage could not be determined.

The Operating Room, sluice gate, and bypass control appear to be in excellent condition (Photograph 10).

The only noteworthy deficiency is the lack of an appropriate locking mechanism on the manhole access to the Outlet Chamber beneath the Control Room. Without the lock, the Control Room could be entered via the Outlet Chamber which opens to the outside at the base of the spillway.

4. Reservoir Area. The general area surrounding the reservoir is characterized by moderate slopes that are light to heavily wooded. Reclaimed strip mines and sealed deep mines occur in the higher elevations, consequently, significant areas of the watershed were revegetated only after the project was initiated. In addition to the reclaimed areas, much of the higher elevation of the watershed is developed agriculturally.

5. Downstream Channel. The Muddly Creek Channel below the dam extends for approximately 4.2 miles to the confluence with Slippery Rock Creek. The slope of the stream channel is gentle as the creek follows a meandering course with numerous oxbow lakes developed along its length. The valley narrows briefly to approximately 400 feet wide about 2,000 feet downstream of the dam. Throughout the remainder of the valley, however, Muddy Creek follows a rather sluggish course through a relatively broad valley with gently sloping valley walls. The character of Muddy Creek changes abruptly near the confluence of Slippery Rock Creek. The last 1,000 feet of Muddy Creek plunges through a narrow gorge in a series of rapids as the creek joins with Slippery Rock Creek.

Within the first mile downstream of the embankment, the moderate valley side slopes are densely wooded. Beyond, the valley broadens and much of the area is in agricultural use. In the higher elevations south of Muddy Creek, there are significant limestone quarries and numerous small sand and gravel pits.

Immediately downstream of the embankment, summer community and amusement area known as Sherwood Park has been abandoned. The buildings have been demolished and only the foundation remnants are in evidence. Approximately 1,000 feet downstream of the embankment within the Sherwood Park area there is an artesian well on the south bank of Muddy Creek and adjacent the ruin locally known as the skating

rink (Photograph 12). An 8-inch steel casing projecting from the ground has been reduced to a 2-inch flow line. Mr. Dickerson reported the well to flow at approximately 50,000 gallons per day. This discharge is reported to be approximately constant since before the construction of the dam.

Approximately 2.2 miles downstream of the embankment there is a small community of 14 dwellings all located in the floodplain of Muddy Creek (Photograph 14). Discussion with a local resident indicated that 13 of the dwellings are occupied on a part-time basis throughout the year. Only one house is occupied full-time. All of these dwellings are considered sufficiently near the creek to be within the effects of an embankment breach. Furthermore, Mr. Dickerson indicated that downstream property damage would result if the reservoir drawdown exceeds one tenth foot per day. The maximum reservoir drawdown rate of the 72-inch sluice gate full open is approximately one foot per day.

3.2 Evaluation.

Observation made during the visual inspection suggests that the overall condition of the facility is good.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Normal Operational Procedures.

Provisions for the day-to-day operation of the facility are presented in a manual entitled "Operation and Maintenance Manual for Moraine State Park Dam, Butler County, Pennsylvania." Included within this manual are procedures relative to conditions requiring normal operation, low flow operation, and flood emergency operation. In addition there are guidelines and procedures for the installation of piezometers and settlement points, drawdown for inspection and maintenance, and for operation during power failure. The manual is available at the Park Office.

According to the manual the 72-inch sluice gate and 12-inch bypass valve remain closed during normal operation. Even during periods of flood the gate and valve are not opened as the spillway section is designed to route all expected flood waters. In fact, these two apparatus are operated only during periods of low flow such as can be expected in the dry summer months. Consequently, the operation of the facility is fairly basic and does not require constant attention.

4.2 Maintenance of Dam.

Provisions for the maintenance of the facility are contained within the manual discussed in Section 4.1. Included are guidelines and procedures for the inspection and maintenance of the dam structure, control building and outlet works, riprap, spillway and trashrack, stilling basin, outlet channel, trash boom, and other appurtenances.

4.3 Maintenance of Operating Facilities.

The dam and its operating facilities are visited daily by park personnel. Maintenance of the operating facilities is performed in accordance with the manual discussed in Sections 4.1 and 4.2.

4.4 Warning Systems.

There are no formal warning systems associated with the operation of this facility.

4.5 Evaluation.

Conversations with the park superintendent reveal his total familiarity with the contents of the operation and maintenance manual. Consequently, the facility appears to be operated and maintained in accordance with the designed procedures.

SECTION 5
HYDROLOGIC/HYDRAULIC EVALUATION

5.1 Design Data.

Information supplied by the PennDER and Michael Baker, Jr., Inc., relative to the hydrology and hydraulics of this project includes a report entitled, "Summary of Hydrological Studies, Hydraulics and Stability Analysis," dated March 1965, by Michael Baker, Jr., Inc. The report is a synopsis of the hydrologic/hydraulic design parameters and separately discusses design criteria, low flow analysis, flood flow analysis, flood routing, tailwater rating curve development, terminal structure hydraulics, outlet works, and stability analysis. In addition to the above report, the design drawings contain a plethora of graphic data (see Figures 2 and 3).

5.2 Experience Data.

Discharge and reservoir levels are recorded daily at the facility. These records coupled with information gathered through discussion with owner's representative relative to the operational history of the facility suggests its adequate past performance.

5.3 Visual Observations.

On the date of the inspection, no conditions were observed that would indicate the appurtenant structures of the dam could not operate satisfactorily during a flood event.

5.4 Overtopping Potential.

The hydraulic design of this facility was based on an in-depth flood routing study. The two primary references used to facilitate the design were:

1. "Design of Small Dams"
   (Bureau of Reclamation)
   Used for Hydrology and Structural Design

2. "Design Criteria for Concrete Gravity and Arch Dams," by
   F. D. Kirn, (Bureau of Reclamation)
   Used for Structural Design

The maximum probable storm was routed through the reservoir. Based on a drainage area of 53 square miles, the probable maximum precipitation for a 6-hour period is 21.9 inches and 32.2 inches for a 48-hour period. The peak inflow during this storm was 113,965 cfs. This storm, when routed through the reservoir developed a maximum pool elevation of 1203.6 (Note: Top of dam elevation 1204.5). The resulting spillway discharge at maximum water level was 12,000 cfs.

Based on empirical data supplied by the Corps of Engineers, Baltimore District, Peak PMF Q (Peak Inflow) = 45,580 cfs for a total rainfall period of 39 hours (see Appendix C). By comparison, it is apparent that the design criteria developed for the facility is more stringent than the screening criteria recommended by the Corps. Consequently, the spillway is deemed adequate.

5.5 Spillway Adequacy.

The spillway has been designed in accordance with techniques and criteria that exceed the requirements of the screening criteria recommended by the Corps of Engineers, Baltimore District. As a result, the spillway is deemed adequate.

SECTION 6
EVALUATION OF STRUCTURAL INTEGRITY

6.1 Visual Observations.

a. Embankment. Based on visual observations, the embankment appeared to be in good condition. In 1970-1971, a damp area was observed in an isolated area along the toe of the north embankment. According to Mr. Dickerson, the condition was closely monitored for an extended period. After 1971, the damp area apparently dried and the vegetative cover in the immediate area again conformed to the cover typically observed in other areas of the embankment. At the time of the current inspection, no damp areas could be detected along the downstream toe of the embankment.

b. Appurtenant Structures.

1. Spillway. The spillway appeared to be in good condition. At the time of the inspection, flow over the ogee-crested spillway, precluded the direct observation of the spillway face.

2. Outlet Works. The inlet conduit, trash rock and stoplog assembly could not be observed as these structures are submerged. The 72-inch sluice gate and bypass were in a closed position at the time of the inspection. The stilling basin and derrick stone-lined channel downstream of the dam appear to be in good condition.

6.2 Design and Construction Techniques.

a. Dam. Available engineering data obtained from PennDER and Michael Baker, Jr., Inc., files indicate the facility has been adequately designed in conformance with modern accepted engineering practices. Miscellaneous construction reports, piezometer data, construction drawing and photographs are also available at the Moraine State Park office.

6.3 Past Performance.

Reservoir level records and rainfall data are kept current by park personnel. According to Mr. Dickerson, Moraine State Park Superintendent, the facility has functioned satisfactorily since its construction.

6.4 Seismic Stability.

The dam is located within Seismic Zone No. 1, and it is thought that the static stability of the structure is sufficient to withstand minor earthquake-induced dynamic forces. However, no calculations, investigations, etc., were performed to confirm this belief.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS FOR REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety. The visual inspection, operational history and available engineering data suggest that the facility is in good condition.

The project is capable of passing the flow resulting from a storm of PMF magnitude without overtopping the dam; therefore, the spillway is considered adequate. The designer anticipates downstream flooding at large discharges, however there would be little effect on the embankment. Flood damage to the downstream channel slope protection is also anticipated and is delineated in the Maintenance Manual.

The only object of concern is the lack of current piezometer readings (the last set of readings were obtained in 1972). Piezometer readings and their analysis should be performed on a regular basis; perhaps annually during periods of high reservoir inflow.

b. Adequacy of Information. The available information is considered adequate to make an accurate assessment of this facility.

c. Urgency. The studies and remedial measures listed below should be carried out as soon as possible.

d. Necessity for Additional Investigations. No additional investigations are deemed necessary at this time.

7.2 Recommendations/Remedial Measures.

It is recommended that:

a. A warning system be developed to provide for the safe evacuation of downstream inhabitants should the need arise. This plan could be incorporated into the "Operation and Maintenance Manual" currently in use. The program should include round-the-clock surveillance during periods of intense or prolonged rainfall.

b. The "Operation and Maintenance Manual" should be revised to include a procedure for installing the stoplog of the outlet works.

c. The manhole which provides access between the outlet chamber and the control room should be secured with a slide bolt or locking mechanism on the control room side. The control room and gate controls are currently accessable to unauthorized persons entering through the outlet chamber.

d. The dam continued to be inspected on an annual basis to detect any hazardous conditions which may develop. It is further suggested that the piezometers be read during the annual inspection and the results compared to the latest data reviewed by Ralph B. Peck and associates. Significant deviations from the latest readings should be evaluated with respect to effects on embankment and spillway stability.

APPENDIX A

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Moraine State Park Dam

ID # PA-273

ITEM	REMARKS	SHEET 1

AS-BUILT DRAWINGS

Complete set of contract drawings as: (1) Moraine State Park Office
(2) PennDER
(3) M. Baker, Inc.

REGIONAL VICINITY MAP

USGS Maps: Prospect, PA 7.5 Minute Quadrangle Map
Park Office had drawing entitled "Base Map, Part of the Master Plan, Moraine State Park" (prepared by Aerial Mapping Company)

CONSTRUCTION HISTORY

Design: M. Baker, Inc., with consulting by Peck, Ireland & Hendron
Construction: John G. Ruhlin Construction Company, 1024 Home Avenue, Akron, Ohio
Started 14 May 65; Closed sluice gate 15 May 69
Inspection: GSA; Dept. of Forest and Waters (resident engineer); M. Baker, Inc.

TYPICAL SECTIONS OF DAM

Contract drawings have cross-sections at 50-foot intervals along centerline of dam.

OUTLETS - PLAN Sheet No. 14 of Contract Drawings

- DETAILS Sheet No. 16 of Contract Drawings

- DISCHARGE RATINGS Detailed on Sheet No. 3 "Hydrological Data"

RAINFALL/RESERVOIR RECORDS

Rain gage at park office read and recorded daily.
Automatic pool level recorder in gate house.
Records available from October 1970 at park office.

ITEM	REMARKS	ID # PA-273	SHEET 2

DESIGN REPORTS

None at park office.
None at Bureau of State Parks Regional Office in Prospect, Pa. (Jim Peace, Regional Engineer).
Brief design review by R. Peck in M. Baker's files - no calculations.
Report entitled "Summary of Hydrological Studies, Hydraulics, and Stability Analysis" by M. Baker, dated March, 1965, in PennDER file.

GEOLOGY REPORTS

Available in Subsurface Investigation Report by M. Baker, Inc.

DESIGN COMPUTATIONS

HYDROLOGY & HYDRAULICS None available from Bureau of State Parks or M. Baker, Inc.
DAM STABILITY Summary Data as indicated under "Design Reports".
SEEPAGE STUDIES

MATERIALS INVESTIGATIONS
BORING RECORDS
LABORATORY
FIELD

(1) 81 borings reported by M. Baker, Inc., in Subsurface Report - Bound copy of logs available at Baker's office in Beaver.
(2) Correspondence in Baker's files indicates 18 triaxial tests, 26 consolidation tests, 13 unconfined compression tests, 153 gradation and Atterberg Limits were conducted. Numerous proctor compaction tests were also conducted.
(3) Field permeability on impervious fill; correspondence indicates compaction control tests.

POST-CONSTRUCTION SURVEYS OF DAM

Six (6) settlement platforms installed during construction. No data, however, is available in files reviewed.

BORROW SOURCES Downstream of dam - located on Sheet 2 of Contract Drawings.

MONITORING SYSTEMS

Sheet No. 29 of Contract Drawings shows plan location of settlement platforms, settlement points, and piezometers. Data was continually evaluated by R. Peck and Associates during construction and reservoir filling.

MODIFICATIONS

None

HIGH POOL RECORDS

June 26, 1972, discharged 1.9 feet over spillway crest.

POST CONSTRUCTION ENGINEERING
STUDIES AND REPORTS

(1) Visual inspection monthly by Bureau of State Parks personnel (non-technical).
(2) Inspected yearly by Park Supt. (Mr. Dickerson). Completes DER inspection checklist.
(3) Inspected yearly by Division of Completed Projects (PA) - Dick Rahn.

PRIOR ACCIDENTS OR FAILURE OF DAM
DESCRIPTION
REPORTS None

MAINTENANCE OPERATION RECORDS

Maintenance and Operations Manuals at Park Office. Maintenance is performed as directed via formal letter from Harrisburg Office upon yearly inspection.

Daily rainfall and pool levels recorded.

ITEM	REMARKS	ID # PA-273	SHEET 4

SPILLWAY PLAN - Sheet No. 14 of Contract Drawings.

SECTIONS
DETAILS — Sheet No. 16 of Contract Drawings.

OPERATING EQUIPMENT PLANS & DETAILS — Sheet Nos. 14 and 16 of Contract Drawings.

CHECK LIST ID # NDI PA-273, PennDER 10-68
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 53 square miles

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1190.0 (38,000 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1190.0

ELEVATION MAXIMUM DESIGN POOL: 1204.5 (98,000 acre-feet)

ELEVATION TOP DAM: 1204.5

SPILLWAY DATA:

a. Crest Elevation 1190
b. Type Concrete overflow with ogee-shaped crest
c. Weir Length 60 feet
d. Channel Length Not applicable
e. Location Spillover Approximate center of embankment
f. Number and Type of Gates None

OUTLET WORKS:

a. Type 6-foot diameter concrete conduit
b. Location Center base of concrete section
c. Entrance Inverts 1158.92
d. Exit Inverts 1157.29
e. Emergency Draindown Facilities same

HYDROMETEOROLOGICAL GAGES:

a. Type (1) Rain Gage; (2) Pool Level Indicator
b. Location (1) Park Office; (2) Gate House
c. Records Park Office (Daily Records)

MAXIMUM NON-DAMAGING DISCHARGE: 1.9 feet in June 26, 1972.

APPENDIX B

CHECK LIST - VISUAL INSPECTION

CHECK LIST
VISUAL INSPECTION
PHASE 1

DAM NAME Moraine State Park Dam COUNTY Butler STATE Pennsylvania ID # NDI PA-273

TYPE OF DAM Earth HAZARD CATEGORY High

DATE(S) INSPECTION 9-6-78 WEATHER Clear & Sunny TEMPERATURE 80°

POOL ELEVATION AT TIME OF INSPECTION 1190.25 M.S.L. TAILWATER AT TIME OF INSPECTION _____ M.S.L.

INSPECTION PERSONNEL:

S. R. Michalski (GAI)	B. Mihalcin (GAI)	M. Dickerson (Park Supt.)
E. J. Mannella (GAI)		
D. L. Bonk (GAI)	J. P. Nairn (GAI)	

D. L. Bonk RECORDER

EMBANKMENT ID# PA-273 Sheet 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Good.	
RIPRAP FAILURES	None observed. The riprap is composed primarily of limestone. Areas of minor deterioration are visible across the upstream slope, however, the majority of the riprap appears to be sufficiently durable. The lower downstream slope as well as the discharge channel immediately beyond the spillway are lined with limestone derrick stone characteristic of, but apparently more durable than the upstream riprap. No evidence of deterioration was visible on the downstream slope or discharge channel. Approximately 25 feet of the discharge channel is lined with a highly durable sandstone.	

EMBANKMENT ID # PA-273 SHEET 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good condition.	
ANY NOTICEABLE SEEPAGE	None observed.	
STAFF GAGE AND RECORDER	A staff gage is painted on the inside face of the right spillway wingwall just upstream of the crest. A reservoir level recorder is housed within the control building located atop the embankment and immediately to the left of the spillway.	
DRAINS	A 4-inch clay pipe is visible along the right side of the spillway channel approximately 25 feet from the base of the spillway. Conversations with the owner's representative indicates this pipe serves as a drain for the piezometer hut located immediately to the right of the spillway near the middle of the downstream slope.	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Evidence of minor cracking is apparent along the visible portions of the spillway wingwall. These cracks have been patched on an as-required basis.	
INTAKE STRUCTURE	Submerged.	
OUTLET STRUCTURE	The outlet structure is located at the base of the spillway. The spillway was discharging during the inspection and consequently, the outlet could not be inspected from the discharge end. Access to the outlet mechanism is provided within the concrete spillway section. A close inspection from the interior of the structure indicates the outlet and its appurtenances to be in good condition.	
OUTLET CHANNEL	The channel immediately beyond the spillway is roughly trapezoidal in shape and is lined with both limestone and sandstone derrick stone for a distance of approximately 100 feet beyond the spillway.	
EMERGENCY GATE	Sluice gate located within the concrete spillway section of the embankment. The gate was closed during the inspection. The 12-inch bypass pipe located within the concrete spillway section was also closed during the inspection.	

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	60-foot long concrete weir with ogee-shaped crest.	
APPROACH CHANNEL	Submerged.	
DISCHARGE CHANNEL	See "Outlet Channel" Sheet 3.	
BRIDGE AND PIERS	Not applicable.	

GATED SPILLWAY ID # SHEET 5

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	U.S.G.S. benchmark located on top of the right spillway wingwall.	
OBSERVATION WELLS	None observed.	
WEIRS	None observed other than spillway.	
PIEZOMETERS	49 piezometers are located at various locations along the embankment. A circular concrete hut designed to house the piezometer operating equipment is located about halfway up the downstream face and to the immediate right of the spillway. The owner's representative present during the inspection indicated that the system has never functioned as designed and that all previous recorded readings were taken individually and manually.	
OTHERS		

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Moderate slopes, the majority of which are heavily wooded.	
SEDIMENTATION	None observed.	

DOWNSTREAM CHANNEL ID # PA-273 SHEET 8

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	A steep ogee-shaped concrete weir discharges into a riprap lined trapezoidal channel. No obstructions or debris were observed.	
SLOPES	Beyond the riprap lined discharge channel, the stream meanders through a heavily wooded valley. The valley walls of Muddy Creek are generally gently sloping immediately downstream of the embankment.	
APPROXIMATE NO. OF HOMES AND POPULATION	Approximately 2 miles downstream of the embankment, a small summer community has developed in the floodplain of Muddy Creek. Of the 1[illegible] existing houses, only one is inhabited full-time, while the others are occupied intermittently throughout the year. Since Muddy Creek is largely used for recreational activities, the population at any one time can vary from a few individuals to several score.	

APPENDIX C

HYDRAULICS/HYDROLOGY

SUBJECT DAM SAFETY INSPECTION
MORAINE STATE PARK DAM

BY DLB DATE 9-1-78 PROJ. NO. 78-501-273

CHKD. BY EJM DATE 9-12-78 SHEET NO. 1 OF 5

gai CONSULTANTS, INC.
Engineers • Geologists • Planners
Environmental Specialists

DAM STATISTICS

MAXIMUM HEIGHT - 55 FEET (REF 1: pg 99)

DRAINAGE AREA - 53 sq. mi (REF 1: pg 99)

STORAGE CAPACITY ≅ 38,000 AC-FT @ NORMAL POOL (REF 1: pg 99)

STORAGE CAPACITY ≅ 98,000 AC-FT @ T/DAM (FIGURE 2)

SIZE CLASSIFICATION

DAM SIZE - LARGE (REF 2: TABLE 1)

HAZARD RATING - HIGH (FIELD OBSERVATION)

REQUIRED SDF - PMF (REF 2: TABLE 3)

REFERENCES

1: "WATER RESOURCES BULLETIN; DAMS, RESERVOIRS, AND LAKES" PENNA. DEPT. OF FORESTS AND WATERS; BULLETIN NO. 5, COMPREHENSIVE WATER RESOURCES PLANNING INVENTORY NO. 1, 1970

2: "RECOMMENDED GUIDELINES FOR SAFETY INSPECTION OF DAMS" DEPT. OF THE ARMY - OFFICE OF CHEIF ENGINEER, APPENDIX D

3: STANDARD HANDBOOK FOR CIVIL ENGINEERS F. S. MERRITT, McGRAW-HILL 1976

SUBJECT DAM SAFETY INSPECTION
MORAINE STATE PARK DAM

BY DLB DATE 9-1-78 PROJ. NO. 78-501-273

CHKD. BY EJM DATE 9-12-78 SHEET NO. 2 OF 5

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PMF (PEAK FLOW)/AREA = 860 CFS/SQ. MI. (REF: C OF E CURVE, OHIO RIVER BASIN)

PMF = (860 CFS/SQ. MI.)(53 SQ. MI.) = 45,580 CFS

PEAK PMF Q = 45,580 CFS = Q_{IMAX}

VOLUME OF INFLOW HYDROGRAPH

$V = \frac{1}{2}(Q_{IMAX})(TIME)$

DURATION TIME = 74 HRS (REF: C OF E CURVE, OHIO RIVER BASIN)

$V = \frac{1}{2}(45,580\ CFS)(74\ HRS)(3600\ SEC/HR)(1\ ACRE/43,560\ SQ.FT)$

V = 139,377 AC-FT

DETERMINE THE AVERAGE RUNOFF REQUIRED TO PRODUCE THE ABOVE VOLUME OF INFLOW

(139,377 AC-FT)(1 SQ. MI./640 ACRES)(12 IN/FT)/(53 SQ. MI.) = 49.3 INCHES

VOLUMES PRODUCED BY RUNOFF IN EXCESS OF 26 INCHES ARE TO BE RECALCULATED USING 26 INCHES AS AN UPPER BOUND.

(26 INCHES)(53 SQ. MI.)(640 ACRES/SQ. MI.)(1 FT/12 IN) = 73,493 AC-FT

VOLUME OF INFLOW (RECALCULATED) = 73,493 AC-FT

SUBJECT DAM SAFETY INSPECTION
MORAINE STATE PARK DAM

BY DLB DATE 9-1-78 PROJ. NO. 78-501-273

CHKD. BY EJM DATE 9-12-78 SHEET NO. 3 OF 5

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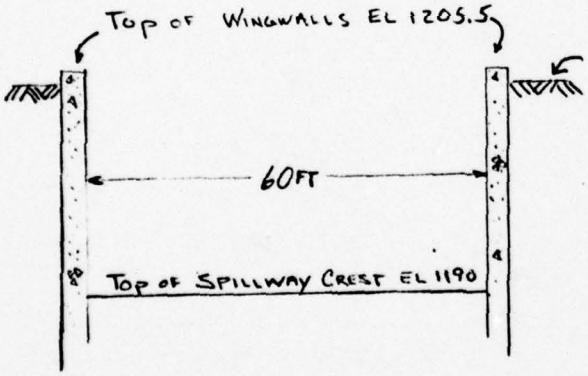
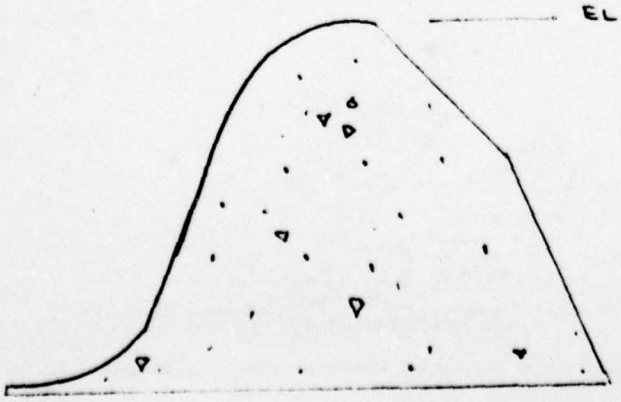
NOTE: $Q_{I_{MAX}}$ REMAINS CONSTANT.
DURATION TIME DECREASES IN ACCORDANCE WITH THE DECREASE IN INFLOW VOLUME

EQUIVALENT DURATION TIME = $[(73{,}493 \text{ AC-FT})(2)(43{,}560 \text{ FT}^2/\text{AC})] / (45{,}580 \text{ CFS})(3600 \text{ SEC/HR})$

$= 39$ HR.

SPILLWAY CAPACITY





NOTE: ALL DETAILS, ELEVATIONS, AND DIMENSIONS ARE TAKEN FROM DESIGN DRAWINGS BY MICHAEL BAKER, JR., INC. DRAWINGS NO. 6 & 8 DATED 2/26/65

SUBJECT DAM SAFETY INSPECTION
MORAINE STATE PARK DAM

BY DLB DATE 9-1-78 PROJ. NO. 78-501-273

CHKD. BY EJM DATE 9-12-78 SHEET NO. 4 OF 5

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$Q = CLH^{3/2}$ (REF 3: EQ 21-121)

L = LENGTH OF SPILLWAY CREST = 60 FT (SHEET 3)

H = MAXIMUM HEAD OVER SPILLWAY CREST =
= (1204.5 - 1190) = 14.5 FT (" ")

C = COEFFICIENT OF DISCHARGE

(FROM REF 3 : FIGURE 21-69)

P/Hd = FOREBAY DEPTH / MAXIMUM HEAD

= 37FT / 14.5 FT = 2.6 (SHEET 3)

ASSUME AN AVERAGE APPROACH SLOPE EQUAL TO 2H : 3V

$\frac{C_{INCLINED}}{C_{VERTICAL}} \simeq 1.0$

(FROM REF 3 : FIGURE 21-67)

$C_{VERTICAL} \simeq 3.95$

$C_{INCLINED} \simeq (1.0)(3.95) = 3.95$

$Q = (3.95)(60FT)(14.5FT)^{3/2} = 13,086$ CFS

PEAK PMF Q (45,580 CFS) > MAXIMUM DISCHARGE (13,086 CFS)
(SHEET 2)

SUBJECT DAM SAFETY INSPECTION
MORAINE STATE PARK DAM

BY DLB DATE 9-1-78 PROJ. NO. 78-501-273

CHKD. BY EJM DATE 9-12-78 SHEET NO. 5 OF 5

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CONSIDER INFLOW RELATIVE TO BOTH OUTFLOW AND STORAGE USING THE SHORT CUT METHOD AS RECOMMENDED BY NAD

$$P = \frac{\text{MAXIMUM DISCHARGE}}{\text{PEAK PMF Q}} = \frac{13{,}086 \text{ CFS}}{45{,}580 \text{ CFS}}$$ (SHEET 1) (SHEET 2)

$P = 0.29$

$$(1-P) = \frac{\text{REQUIRED RESERVOIR STORAGE}}{\text{INFLOW VOLUME}} = 0.71$$

REQUIRED RESERVOIR STORAGE = $(0.71)(73{,}493 \text{ AC-FT})$ ← (SHEET 2)

$= 52{,}180 \text{ AC-FT}$

STORAGE CAPACITY @ 1190 (TOP OF SPILLWAY) $\simeq$ 38,000 AC-FT

STORAGE CAPACITY @ 1204.5 (TOP OF EMBANKMENT) $\simeq$ 98,000 AC-FT

NOTE: VALUES FOR STORAGE ARE TAKEN FROM THE STORAGE - AREA VS. ELEVATION CURVE ON DRAWING 3 OF THE DESIGN DRAWINGS

STORAGE AVAILABLE $\simeq (98{,}000 - 38{,}000)$ AC-FT $\simeq$ 60,000 AC-FT

STORAGE AVAILABLE (60,000 AC-FT) > STORAGE REQUIRED (52,000 AC-FT)

APPENDIX D

PHOTOGRAPHS

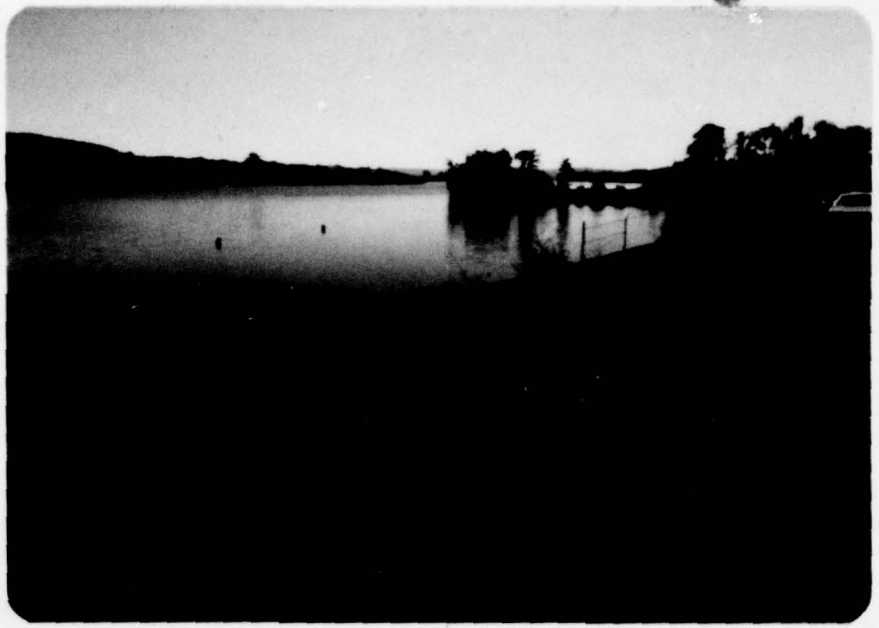
PHOTOGRAPH 1 This view is looking southeast toward Lake Arthur from the crest of Moraine State Park Dam.

PHOTOGRAPH 2 View of the embankment crest, Lake Arthur and the approach to the service spillway.

PHOTOGRAPH 3 View of the service spillway, outlet works, stilling basin, and discharge channel. The derrick stone wall in the left side of this view was reconstructed in the spring of 1978.

PHOTOGRAPH 4 This view is looking downstream of the embankment. The new derrick stone wall can be seen on the far side of the Muddy Creek Channel.

1



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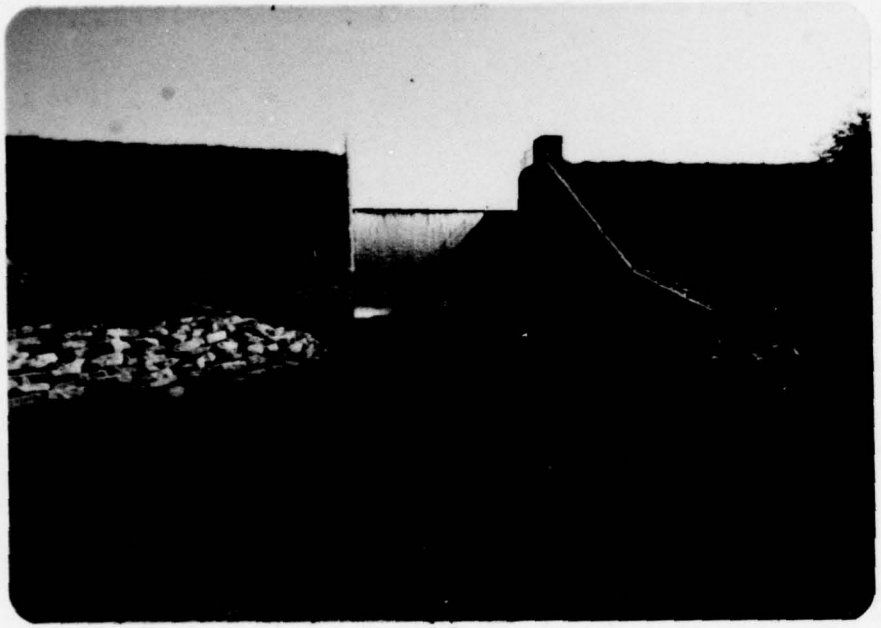

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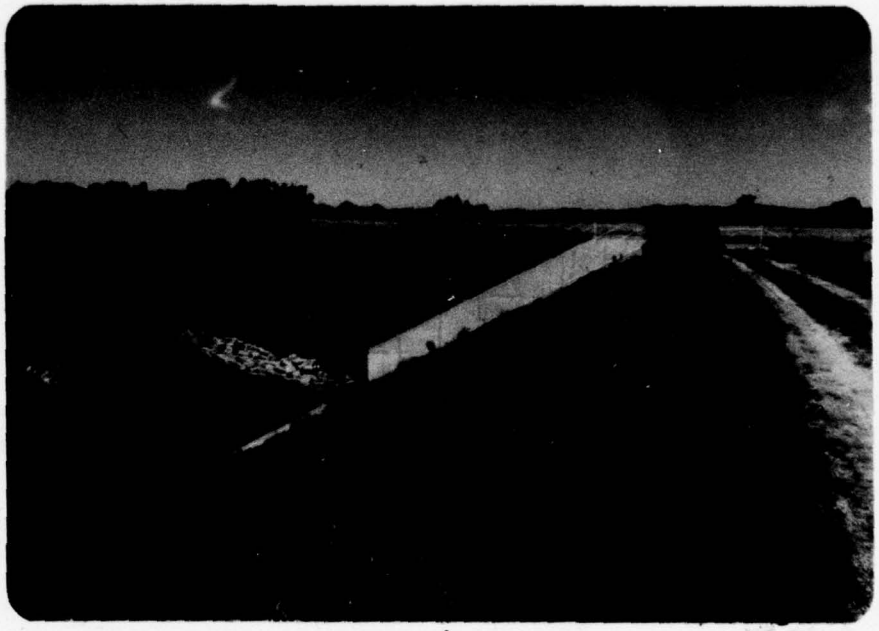


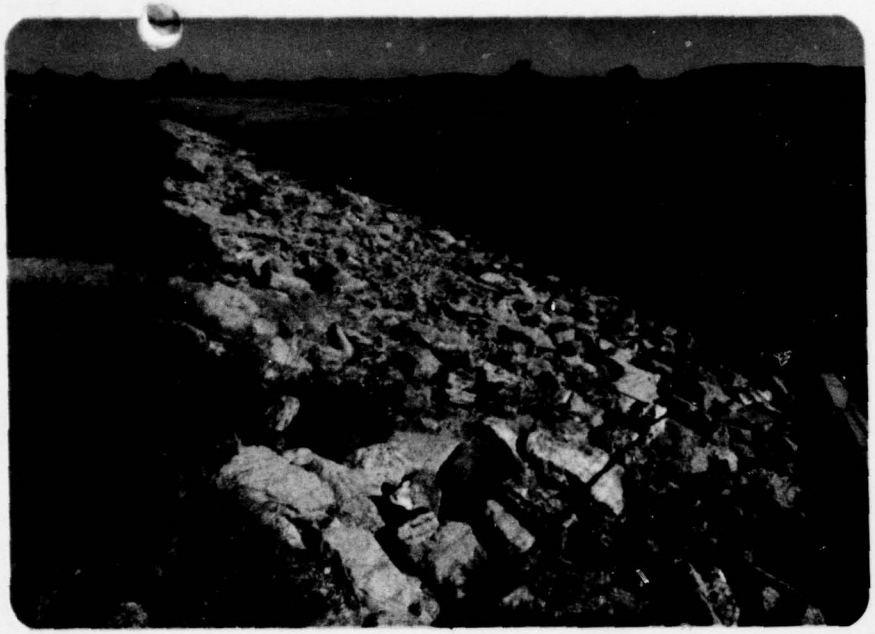
4

PHOTOGRAPH 5 Detailed view of the riprap slope protection on the upstream side of the embankment. The concrete wingwall in the lower right corner of the photograph is part of the approach channel to the service spillway.

PHOTOGRAPH 6 This is an overview of the embankment as seen from the left abutment.

PHOTOGRAPH 7 Looking southeast along the downstream slope of the embankment. The area in the foreground is on the 10H:1V slope which steepens to a 2H:1V slope just right of center.

PHOTOGRAPH 8 Detailed view of exposed riprap on the downstream toe of the embankment immediately west of the stilling basin. The pipe in the foreground is Piezometer No. 8.



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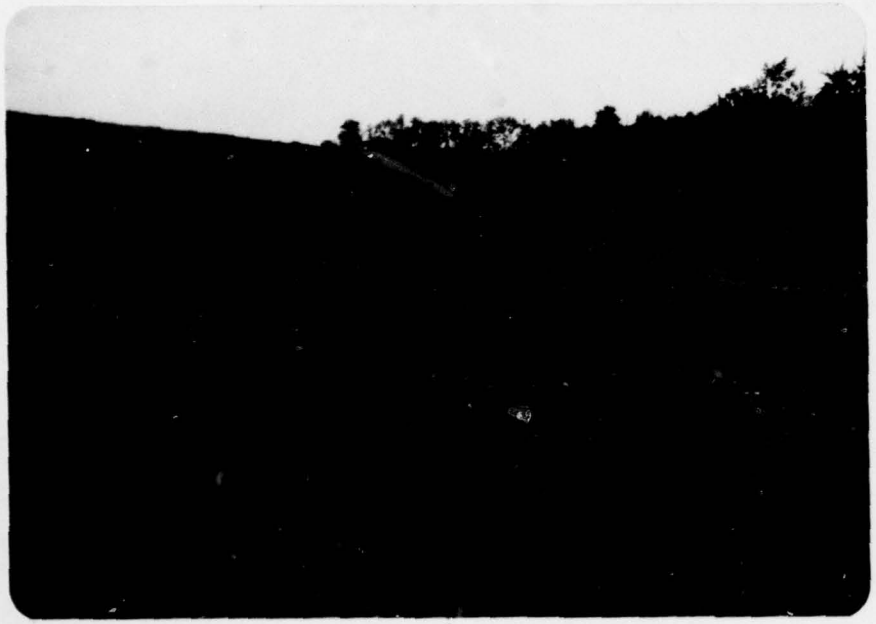

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8

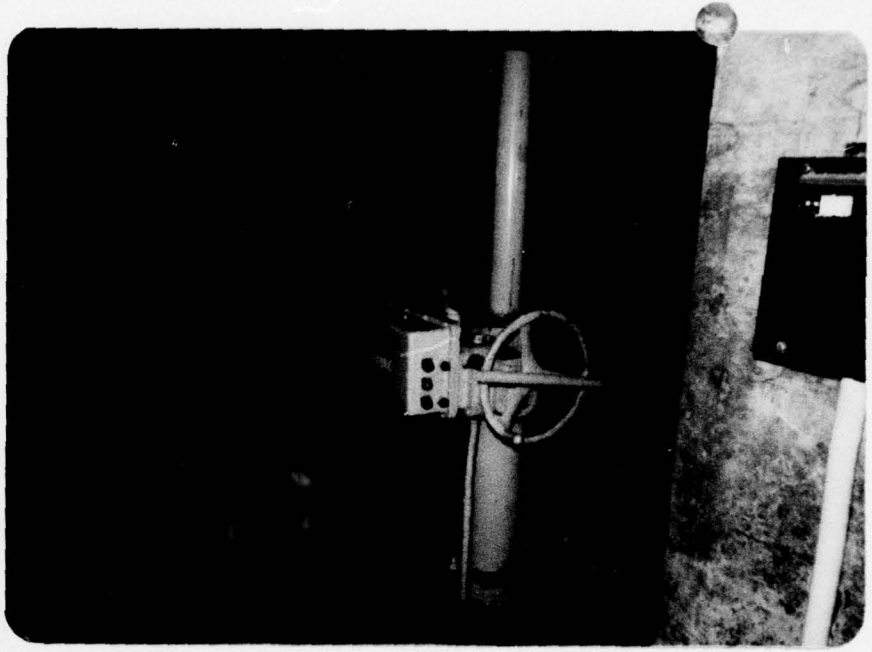
PHOTOGRAPH 9 This view shows the interior of the control buiding which is situated on the crest of the embankment adjacent the spillway. The stage recorder and float well lie left of center. The caged ladder access to the control room is in the background.

PHOTOGRAPH 10 The control room lies directly under the center of the spillway. The large valve in the foreground is the sluice gate control. The smaller floor stand valve in the far corner operates the 12-inch bypass gate. The manhole in the floor provides access to the sluice gate and bypass piping.

PHOTOGRAPH 11 This detail shows the sluice gate (foreground) and the outlet of the 12-inch bypass gate (upper left).

PHOTOGRAPH 12 This is a view of an artesian well located approximately 1,000 feet downstream of the spillway. The well is reported to flow at approximatley 50,000 gallons/day both before and after construction of the dam.

9



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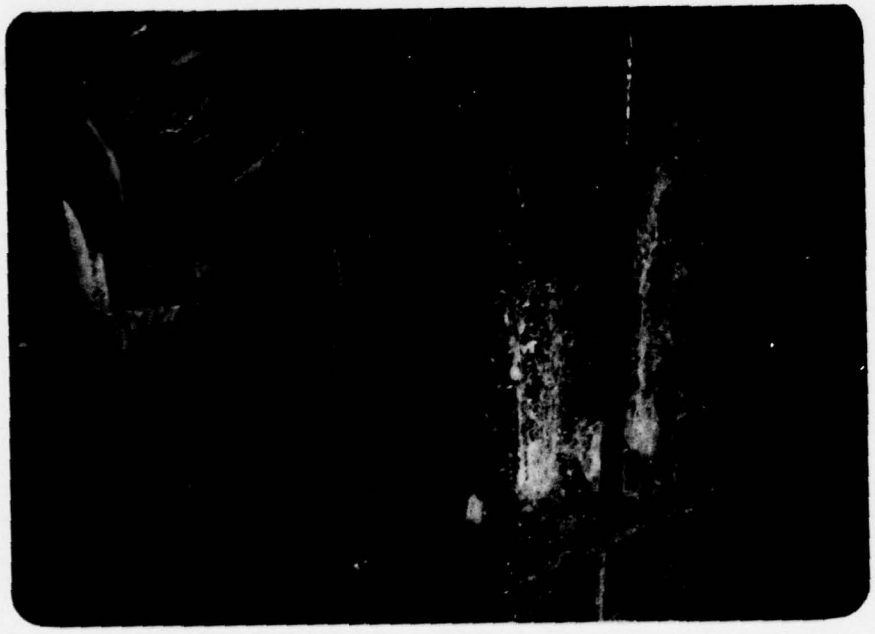


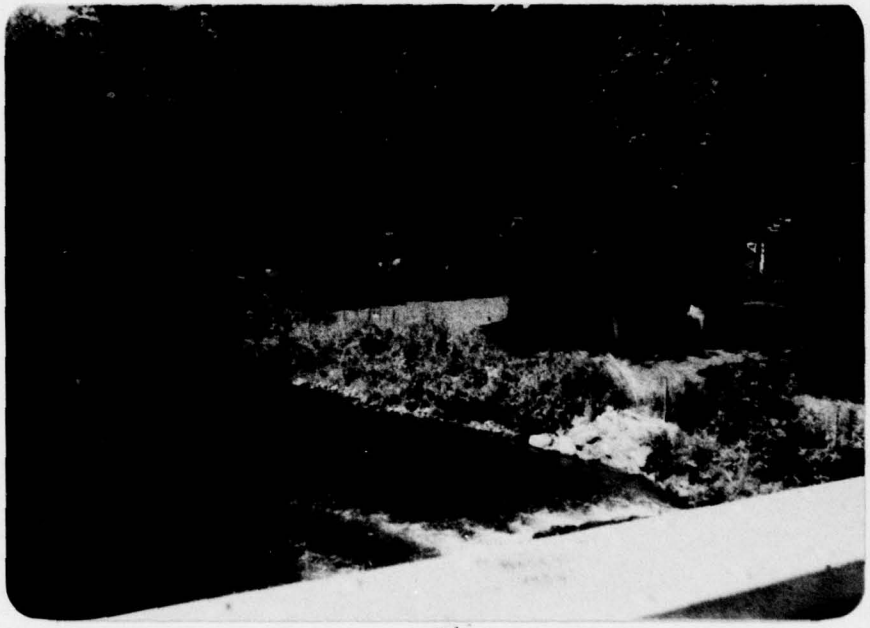
11

12

PHOTOGRAPH 13 The bridge in this view is the first stream obstruction located approximately 2,000 feet downstream of the spillway.

PHOTOGRAPH 14 This small community of 13 summer homes and 1 primary home lies approximately 2 miles downstream of the embankment.

13



14

APPENDIX E

GEOLOGY

The site of the Moraine State Park Dam is located along the southern terminus of the glaciated portion of the Appalachian Plateau Physiographic Province.

In pre-glacial times, Muddy Creek cut a deep valley approximately following the present course of the stream but bearing northwestward across the area of the dam site and joining Slippery Rock Creek considerably north of the present junction. Erosion cut downward through sedimentary strata and the stream flowed along a channel located in the Homewood Sandstone, some 90 to 120 feet below the present channel elevation.

As the continental ice sheet advanced, the western outlet of Muddy Creek was filled and firmly blocked by sand and gravel. Blockage of the Muddy Creek channel caused the formation of Lake Watts, an glacial lake with the approximate conformation of the existing Lake Arthur.

After the retreat of the glaciers, the drainage of Muddy Creek reverted to its preglacial runoff volume, and began cutting a new channel superimposed on the lake sediments that filled the old valley. The stream followed the path of least resistance, cutting the deep gorge at Portersville Station, rather than crossing the morainal deposits filling the old channel. Fractures, solution channels, and porous zones within the Vanport Limestone resulted in underground drainage, erosion, and finally formation of the shorter route joining Slippery Rock Creek.

The present course of Muddy Creek follows the general pattern of the old valley, over accumulations of as much as 100 feet of silt and clay lake sediments, turning west to pass through the gorge, near the encounter with the morainal sand and gravel deposits blocking the old channel.

The relatively recent drainage pattern of Muddy Creek has been influenced predominantly by the glacial deposits. The structural attitude of the surrounding rock formations exerts little or no influence on the present meandering course of the stream.

The regional dip in the area averages 14 feet to the mile, dipping to the southeast. North of the dam site, a shallow anticlinal axis, striking towards the southeast, follows the same general conformation as Muddy Creek Valley. Muddy Creek lies on the gently dipping southern flank of this anticline. South and west of Muddy Creek, structural highs indicate that Muddy Creek Valley coincides with a shallow synclinal trough. Regional dip tends to flatten out the anticlinal structure on the south flank of Muddy Creek Valley.

The course of Muddy Creek tends to be confined to the structural low, and loss of water due to seepage from the reservoir is not probable on the northern flanks of the valley. To the south, the permeable Vanport Limestone formation is deeply covered by impermeable clays and fine silts.

The area of the embankment, therefore, is underlain by a thick sequence of unconsolidated sediments deposited by glacial Lake Watts. This material is often a hundred feet or more thick blanketing the hillsides and filling the prexisting valley. These glacial lake deposits were formed during the advance of the Kent ice sheet of Wisconsin age.

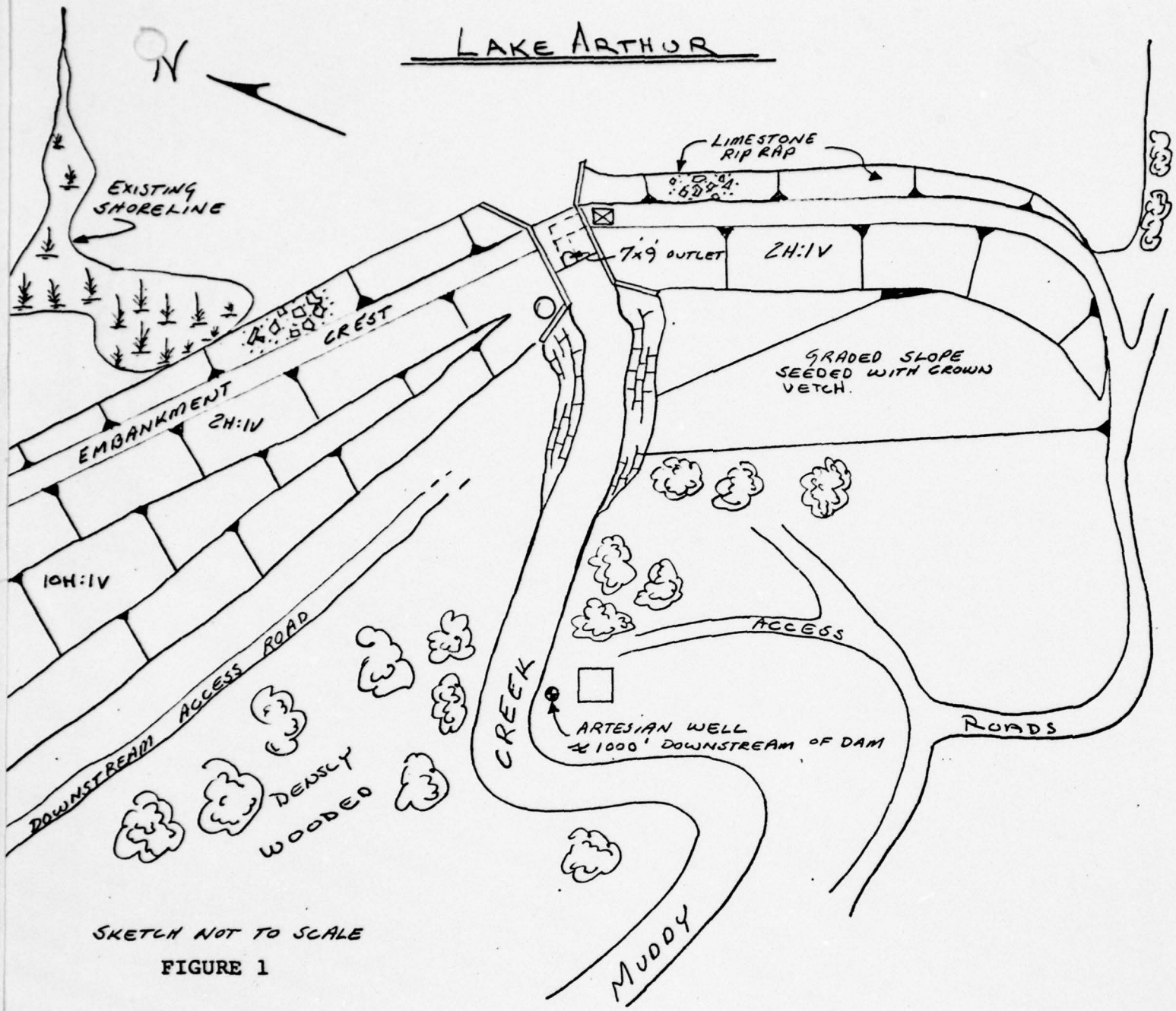
Underlying the glacial lake deposits and the spillway section in the middle of the embankment are consolidated sedimentary rocks of the lower portion of the Allegheny and upper portion of the Pottsville Formations of Pennsylvanian age. These formations consist of nearly horizontal, thin bedded shales, sandstones, and limestone.

Of special interest is the occurrence of the Vanport Limestone underlying the lake deposits on the south (left) abutment. The limestone generally occurs below elevation 1170 and varies from 7 to 14 feet in thickness. The limestone does not occur below the bedrock formation of the concrete spillway section of the dam. The Vanport was quarried immediately southwest of the embankment. This abandoned quarry was ultimately filled and graded during construction of the embankment. Several miles west and northwest of the site the limestone is known to contain significant cavern development. Beneath the south abutment, however, the limestone varies from hard to medium hard with few to some clay seams and occasional small voids.

APPENDIX F

FIGURES

LIST OF FIGURES



SKETCH NOT TO SCALE

FIGURE 1

SUBJECT Moraine State Park Dam

BY SRM DATE 9-13-78 PROJ. NO. 78-501-273

CHKD. BY _____ DATE _____ SHEET NO. 1 OF 1

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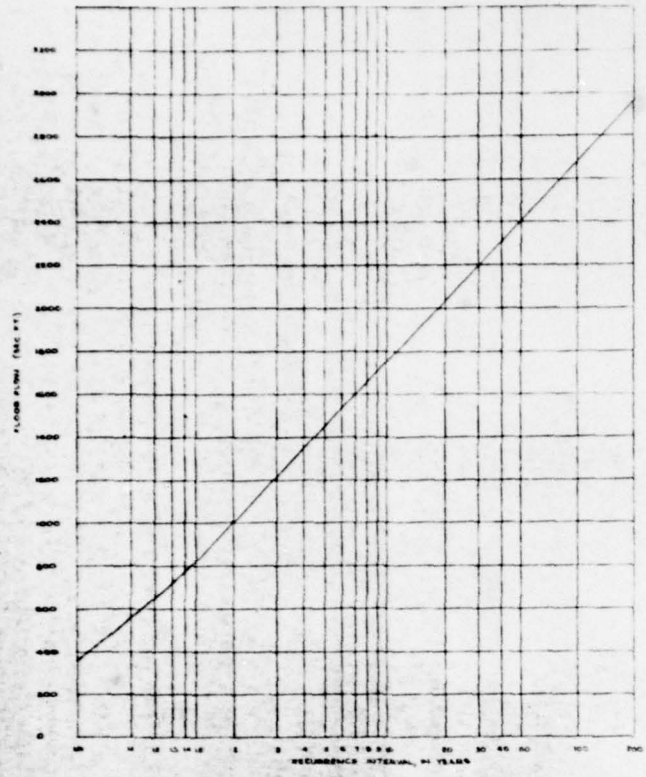
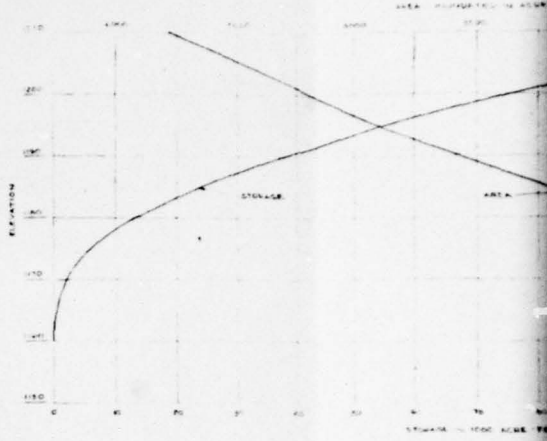
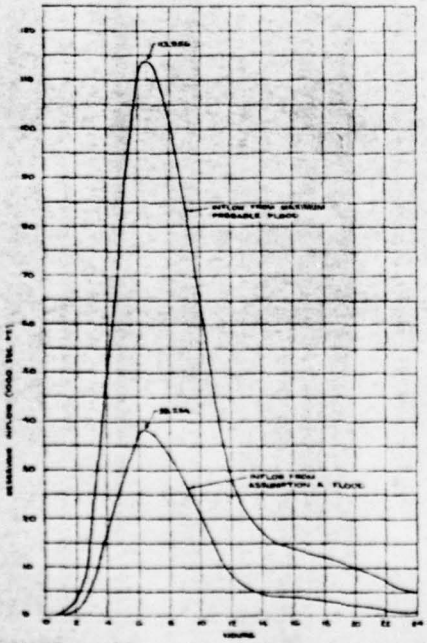


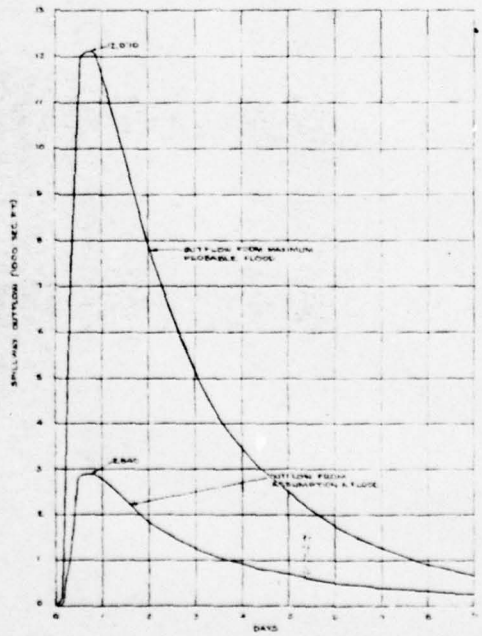
FLOOD FREQUENCY CURVE



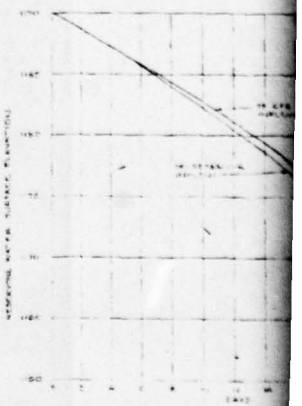
STORAGE - AREA CURVES



RESERVOIR INFLOW HYDROGRAPH

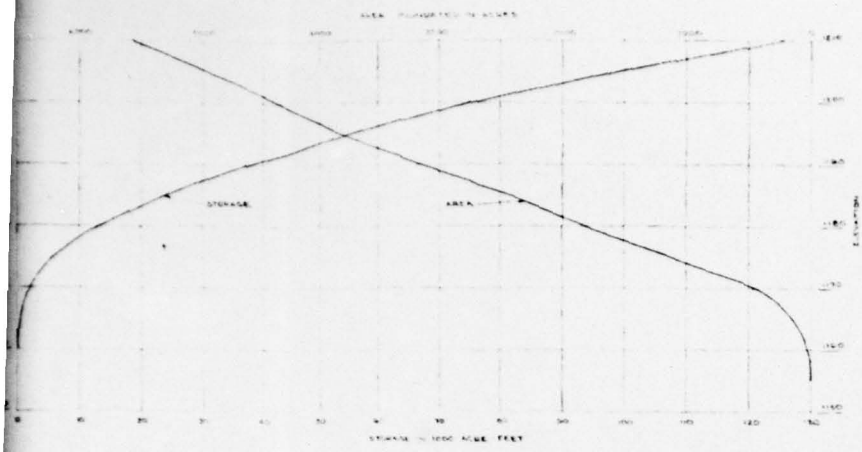


RESERVOIR OUTFLOW HYDROGRAPH

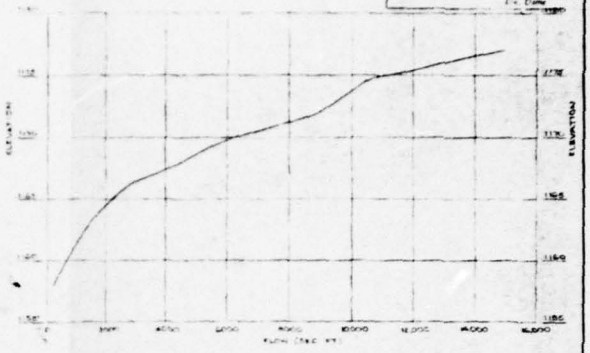


DRAWDOWN CURVE

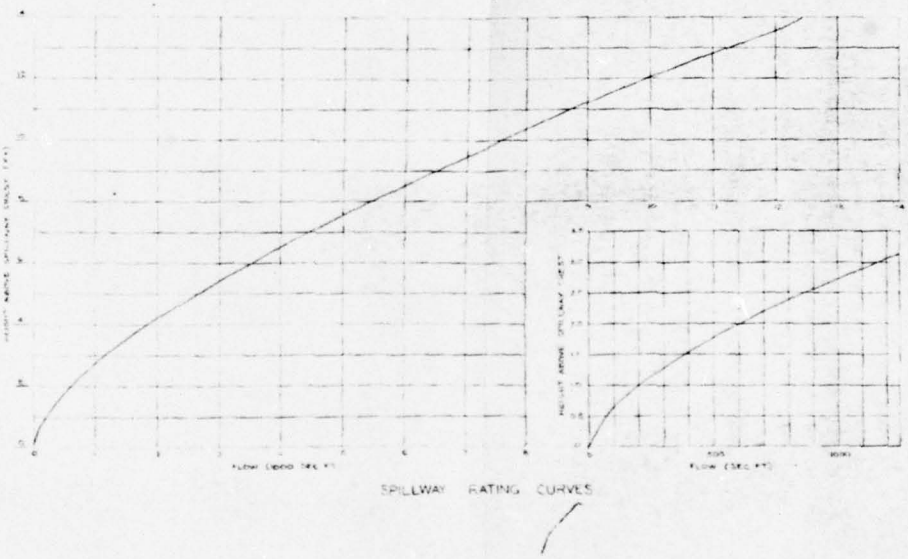
10-C8-3



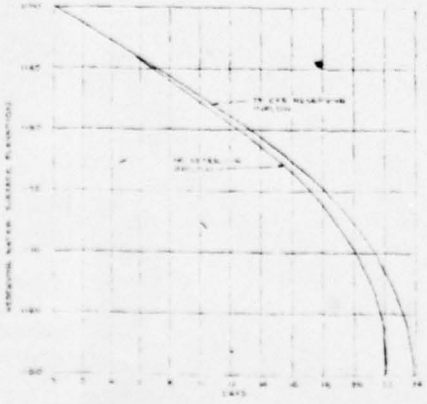
STORAGE - AREA CURVES



TAILWATER CURVE



SPILLWAY RATING CURVES



DRAWDOWN CURVE 8 FT DIAMETER CONDUIT

FIGURE 2

SYMBOL	REVISIONS

APPROVED
CHIEF - DIVISION OF FLOOD CONTROL

APPROVED
ASSISTANT DIRECTOR OF ENGINEERING - G.S.A.

CHECKED BY THE GENERAL STATE AUTHORITY

STR. | ELECT. | MISC.

DESIGNED BY
DEPT. OF FORESTS & WATERS

ENGINEER

DATE

THE GENERAL STATE AUTHORITY
HARRISBURG PENNSYLVANIA

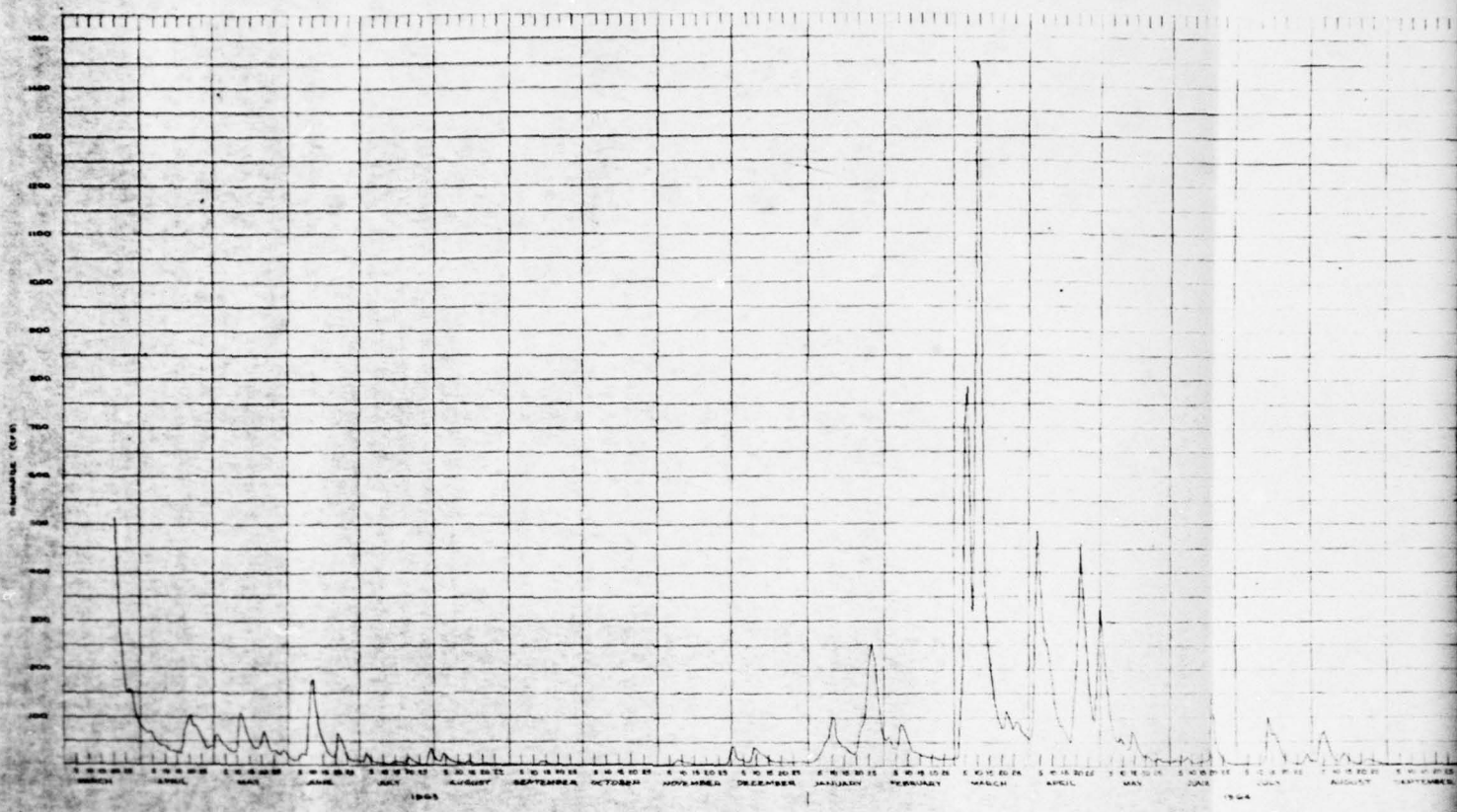
PROJECT NO. G.S.A. - 192-1

MORAINE STATE PARK
DAM
BUTLER COUNTY PENNSYLVANIA

MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER, PENNSYLVANIA

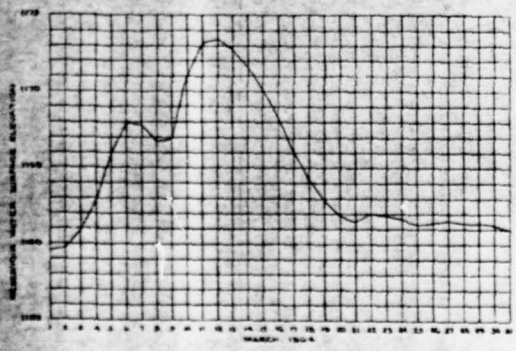
HYDROLOGICAL DATA

DRAWN BY	CHECKED BY	DATE	SCALE	DRAWING NO.
D.S.L.		2/28/63	NONE	3



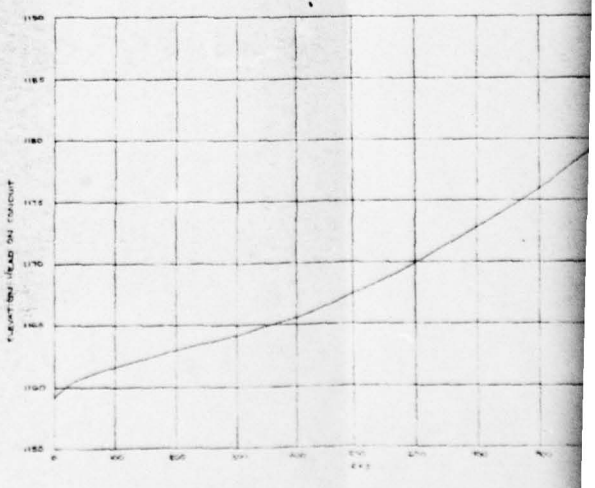
MUDDY CREEK STREAM FLOW DATA

U.S.G.S. PROVISIONAL RECORDS OBTAINED FROM TEMPORARY STREAM GAGE LOCATED AT ROUTE 468 BRIDGE CROSSING MUDDY CREEK.



ROUTING OF MARCH 1964 FLOOD THROUGH 6 FT. DIAM CONDUIT

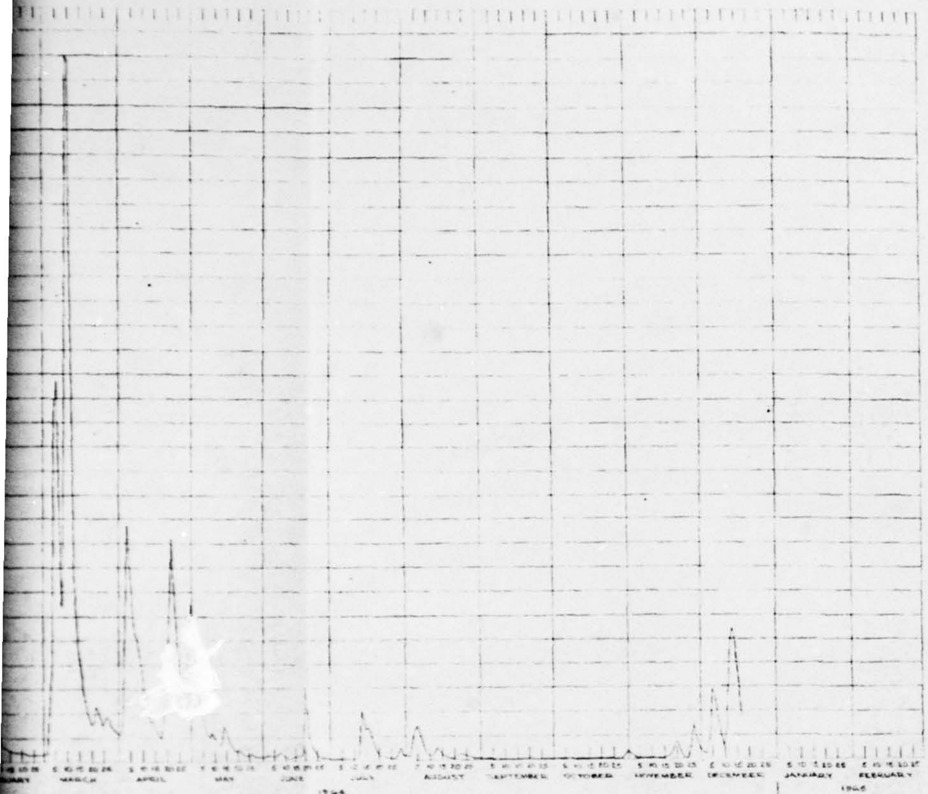
INDICATING REQUIRED RESERVOIR WATER SURFACE ELEVATION TO PASS THE FLOOD



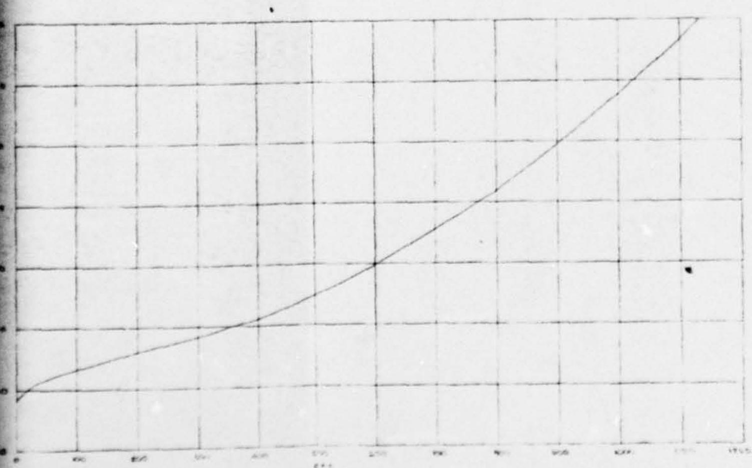
HEAD V^s FLOW 6 FT. DIAM. CONDUIT

10-GE-4
FILE NUMBER
RECEIVED IN THE OFFICE OF THE WATER & POWER RESOURCES BOARD - DEPARTMENT OF FORESTS & WATERS ON THE ___ DAY OF ___ A.D. 19__
File Clerk

REC'D ___ FOR ___
SEE REPORT NO. ___
File Clerk



...LOW DATA



HEAD Vs FLOW 6 FT. DIAM. CONDUIT

FIGURE 3

SYMBOL	REVISIONS

APPROVED
CHIEF - DIVISION OF FLOOD CONTROL

APPROVED
ASSISTANT DIRECTOR OF ENGINEERING - G.S.A.

CHECKED BY THE GENERAL STATE AUTHORITY

STRUC. ELECT. MISC.

CHECKED BY DEPT. OF FORESTS & WATERS

THE GENERAL STATE AUTHORITY
HARRISBURG PENNSYLVANIA

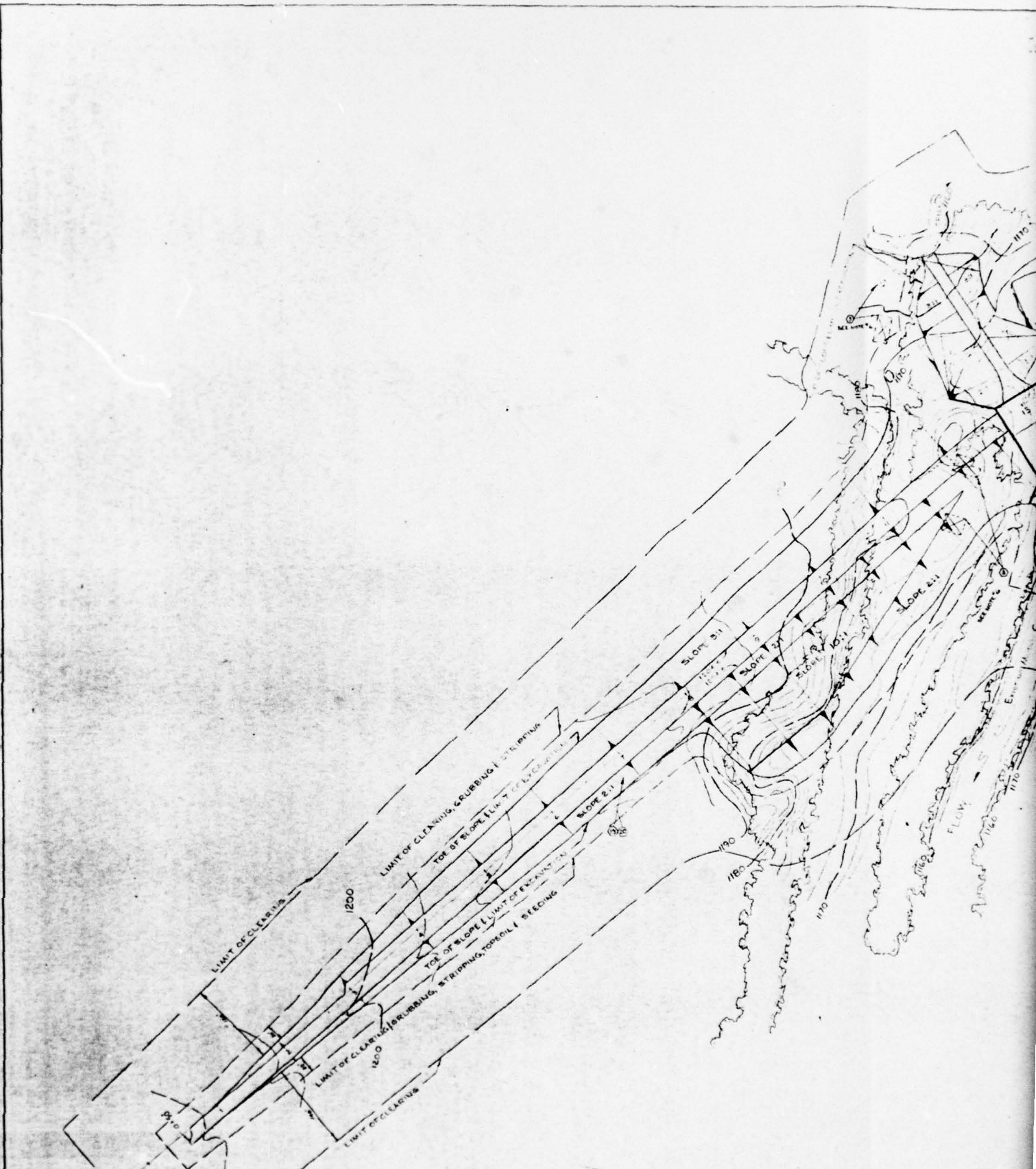
PROJECT NO. G.S.A. - 192-1

MORAINE STATE PARK
DAM
BUTLER COUNTY PENNSYLVANIA

MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER PENNSYLVANIA

HYDROLOGICAL DATA

DATE	DRAWN BY	CHECKED BY	DATE	SCALE	DRAWING NO.
	D.S.S.	[illegible]	1/26/65	NONE	4


LIMIT OF CLEARING
LIMIT OF CLEARING, GRUBBING & STRIPPING
TOE OF SLOPE & LIMIT OF EXCAVATION
SLOPE 2:1
TOE OF SLOPE & LIMIT OF EXCAVATION
LIMIT OF CLEARING, GRUBBING, STRIPPING, TOPSOIL & SEEDING
LIMIT OF CLEARING
1200
1200
SLOPE 3:1
SLOPE 2:1
SLOPE 10:1
SLOPE 2:1
1190
1180
1170
1160
FLOW

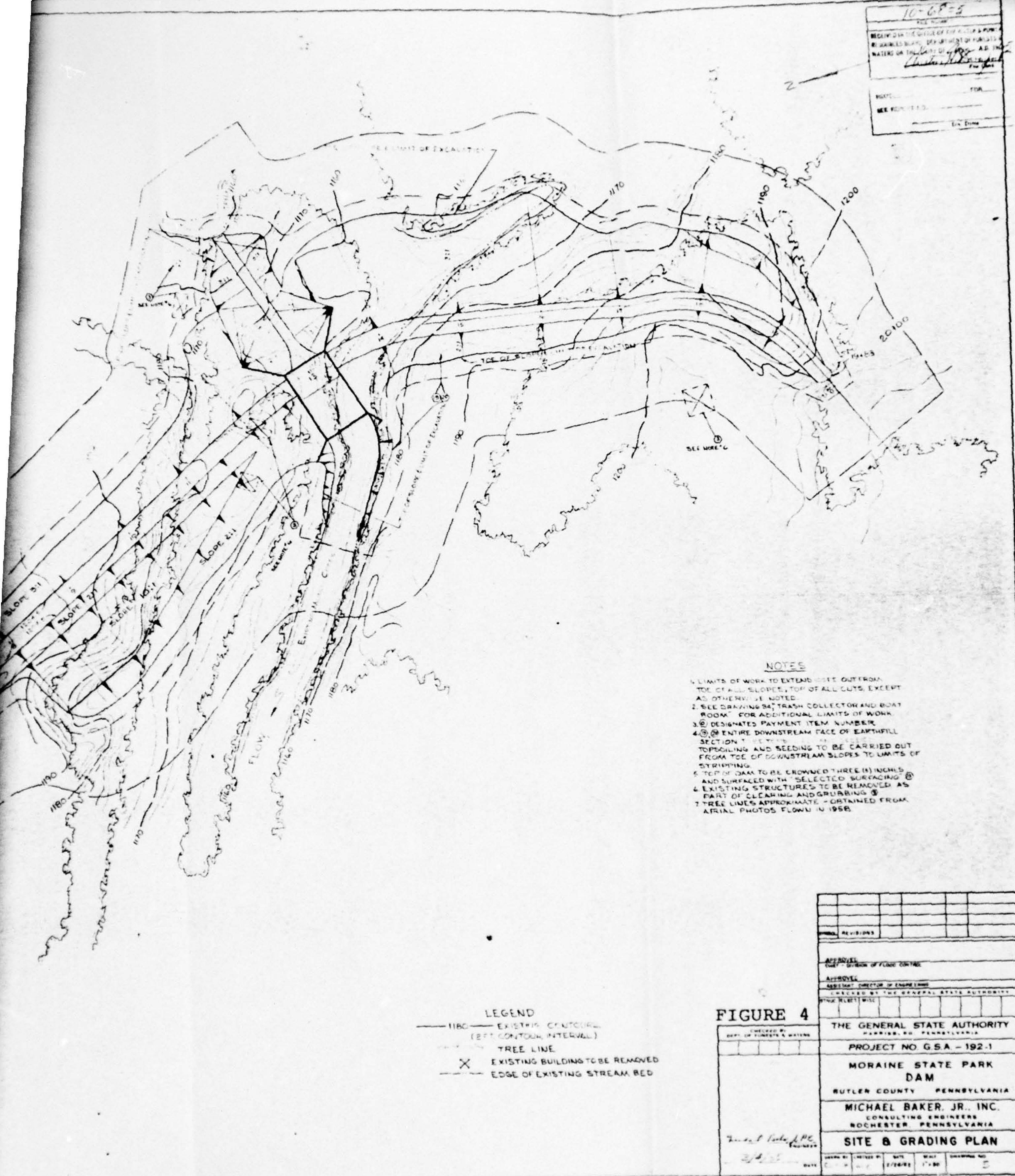
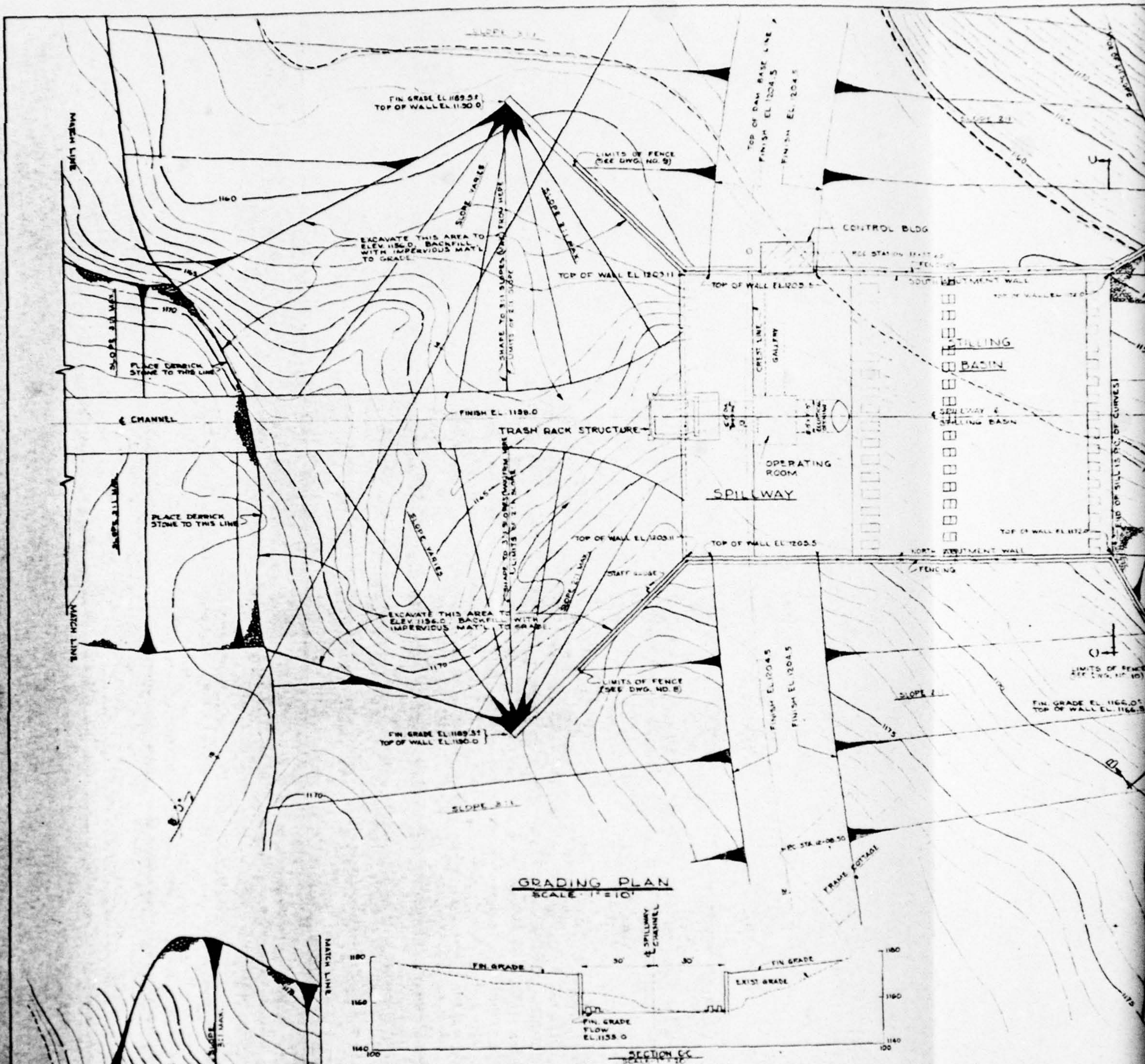
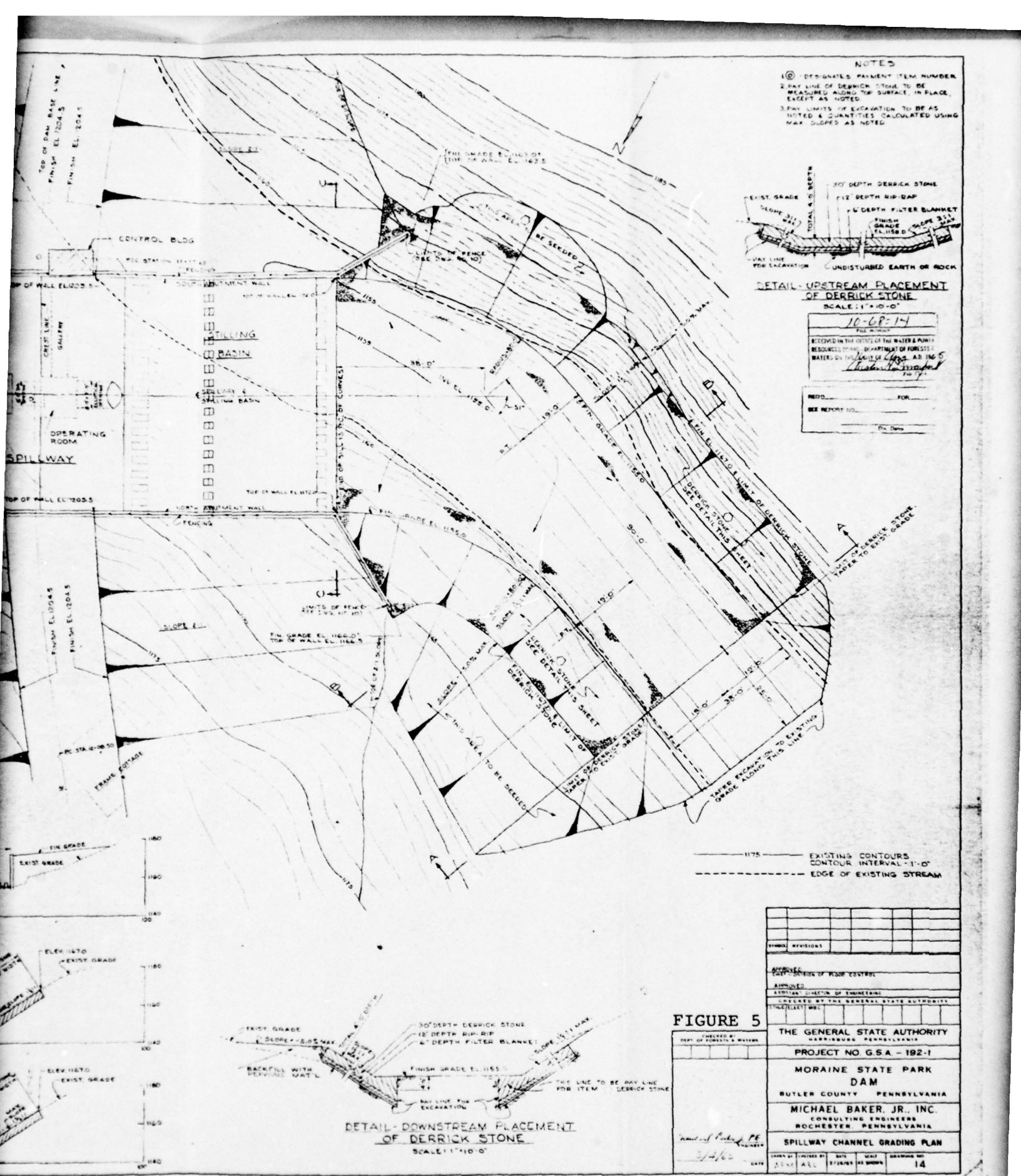
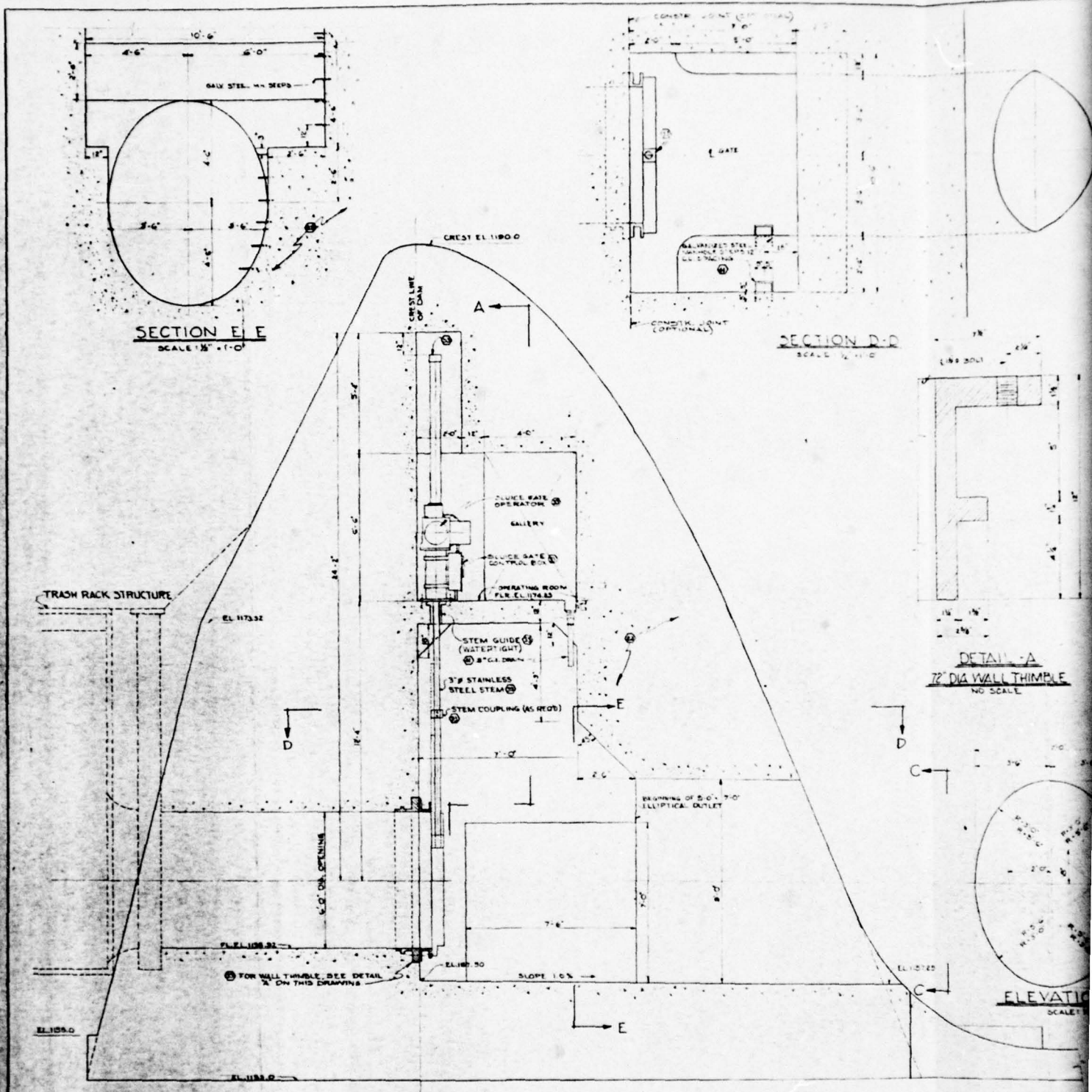

LIMIT OF EXCAVATION
TOE OF BERM
SLOPE 3:1
SLOPE 2:1
SLOPE 10:1
FLOW
SEE NOTE 6
1160
1170
1180
1190
1200
NOTES
1. LIMITS OF WORK TO EXTEND FT. OUT FROM TOE OF ALL SLOPES, TOP OF ALL CUTS, EXCEPT AS OTHERWISE NOTED.
2. SEE DRAWING 34, "TRASH COLLECTOR AND BOAT ROOM" FOR ADDITIONAL LIMITS OF WORK.
3. DESIGNATES PAYMENT ITEM NUMBER.
4. ENTIRE DOWNSTREAM FACE OF EARTHFILL SECTION
TOPSOILING AND SEEDING TO BE CARRIED OUT FROM TOE OF DOWNSTREAM SLOPES TO LIMITS OF STRIPPING.
5. TOP OF DAM TO BE CROWNED THREE (3) INCHES AND SURFACED WITH "SELECTED SURFACING"
6. EXISTING STRUCTURES TO BE REMOVED AS PART OF CLEARING AND GRUBBING
7. TREE LINES APPROXIMATE - OBTAINED FROM ARIAL PHOTOS FLOWN IN 1958
LEGEND
1180 — EXISTING CONTOURS (2 FT. CONTOUR INTERVAL)
TREE LINE
X EXISTING BUILDING TO BE REMOVED
EDGE OF EXISTING STREAM BED
REVISIONS
APPROVEL
CHIEF - DIVISION OF FLOOD CONTROL
APPROVEL
ASSISTANT DIRECTOR OF ENGINEERING
CHECKED BY THE GENERAL STATE AUTHORITY
STRUC. ELECT. MISC.
CHECKED BY DEPT. OF FORESTS & WATERS
ENGINEER
DATE
THE GENERAL STATE AUTHORITY
HARRISBURG, PENNSYLVANIA
PROJECT NO. G.S.A. - 192-1
MORAINE STATE PARK
DAM
BUTLER COUNTY PENNSYLVANIA
MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER, PENNSYLVANIA
SITE & GRADING PLAN
DRAWING NO. 5

FIGURE 4

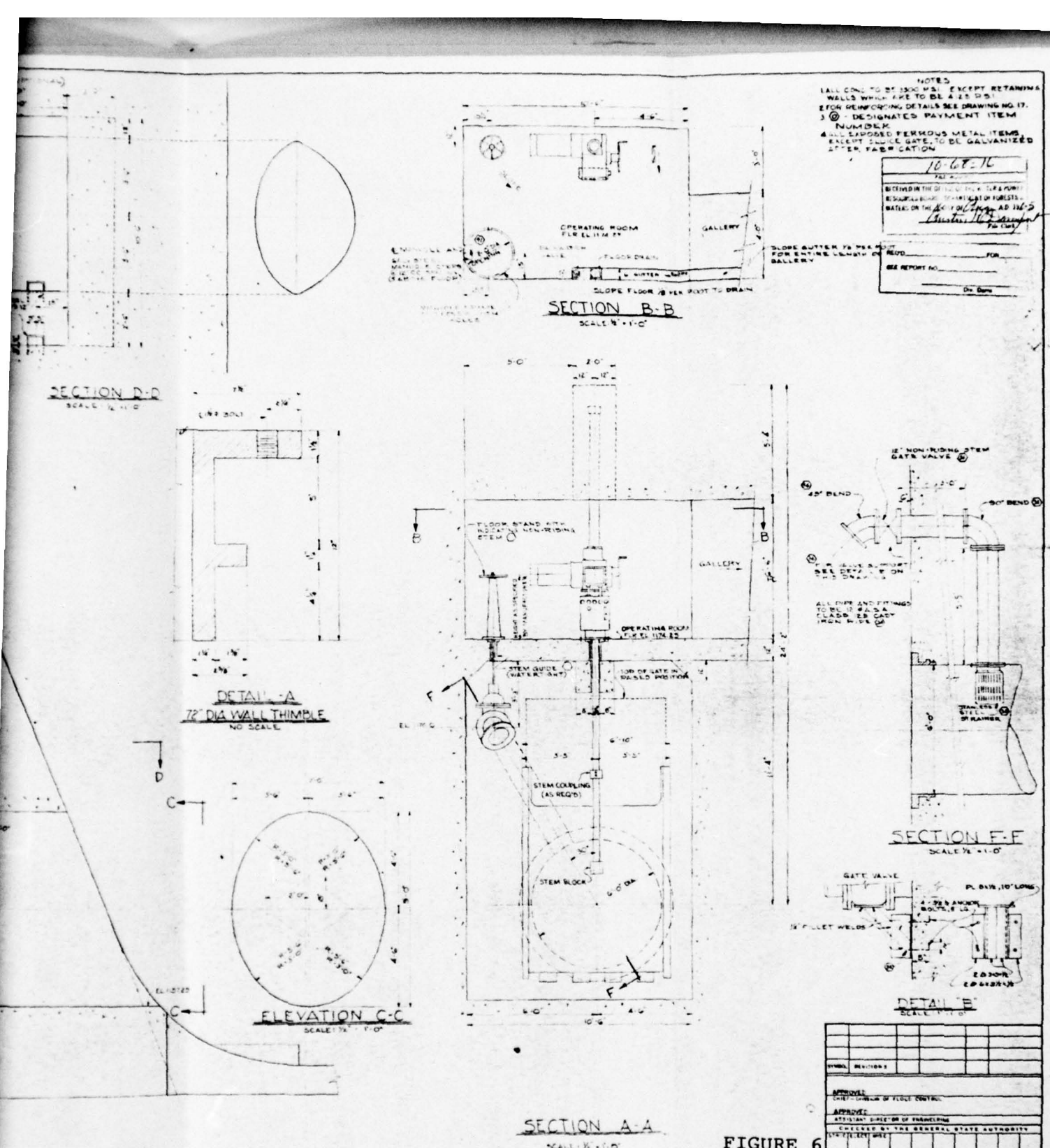


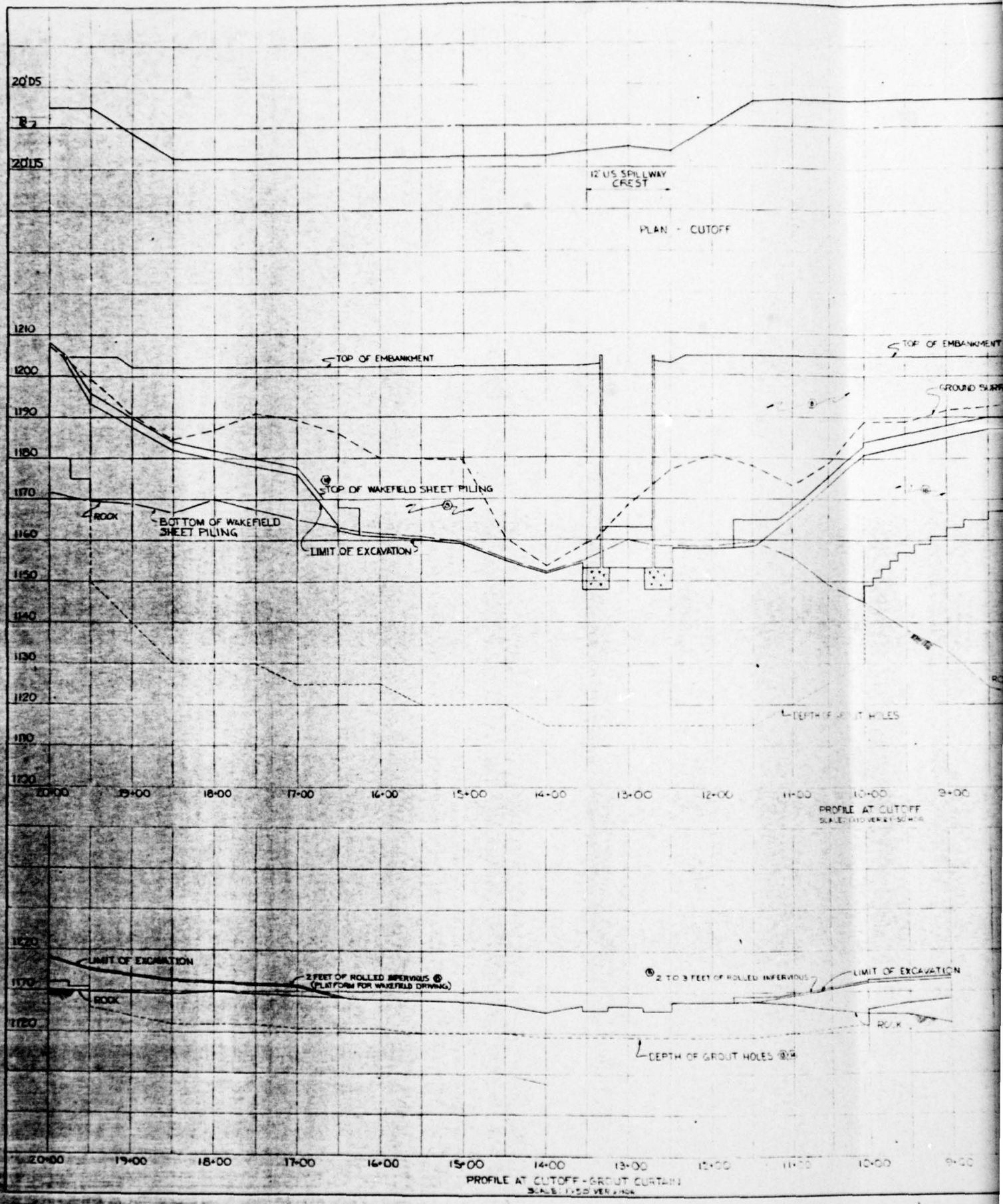
GRADING PLAN
SCALE 1" = 10'
SECTION C-C
SECTION B-B
SECTION A-A
SCALE 1" = 20'
CONTROL BLDG
STILLING BASIN
SPILLWAY
OPERATING ROOM
TRASH RACK STRUCTURE
℄ CHANNEL
FINISH EL. 1138.0
SOUTH ABUTMENT WALL
NORTH ABUTMENT WALL
TOP OF WALL EL. 1205.5
TOP OF WALL EL. 1203.11
FIN. GRADE EL. 1189.5±
TOP OF WALL EL. 1130.0
LIMITS OF FENCE (SEE DWG. NO. 9)
LIMITS OF FENCE (SEE DWG. NO. 8)
EXCAVATE THIS AREA TO ELEV. 1136.0. BACKFILL WITH IMPERVIOUS MAT'L TO GRADE.
PLACE DERRICK STONE TO THIS LINE
MATCH LINE
SLOPE VARIES
TOP OF DAM BASE LINE
FINISH EL. 1204.5
FIN. GRADE EL. 1166.0±
TOP OF WALL EL. 1166.5
DERRICK STONE TO BE PLACED TO FINISH GRADE IN CHANNEL AND 3:1 MAX. SIDE SLOPES. SEE DETAIL THIS SHEET.
FIN. GRADE
EXIST. GRADE
FIN. GRADE FLOW EL. 1138.0
ELEV. 1167.0
BACKFILL WITH PERVIOUS MAT'L

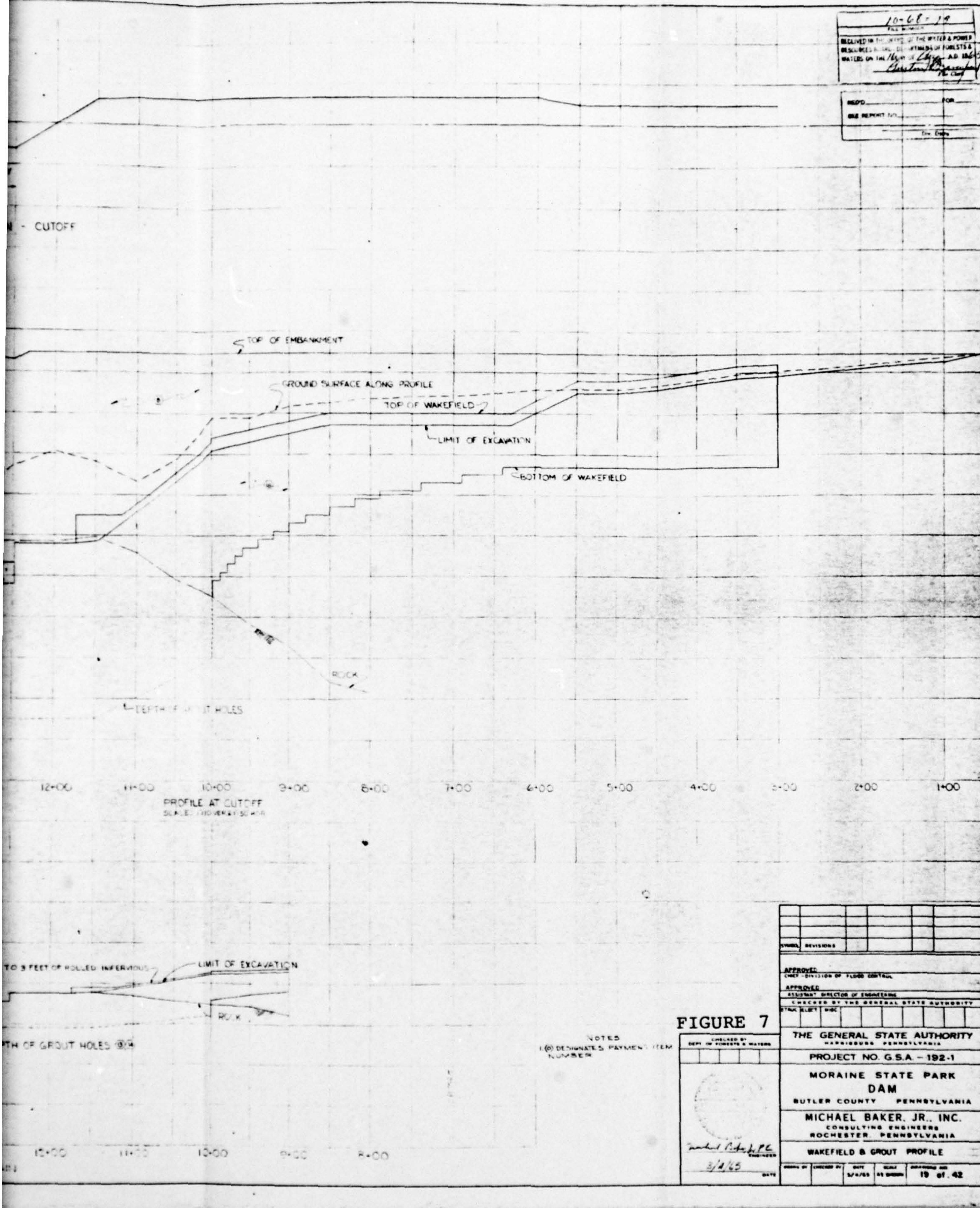

NOTES
1. © - DESIGNATES PAYMENT ITEM NUMBER
2. PAY LINE OF DERRICK STONE TO BE MEASURED ALONG TOP SURFACE, IN PLACE, EXCEPT AS NOTED
3. PAY LIMITS OF EXCAVATION TO BE AS NOTED & QUANTITIES CALCULATED USING MAX. SLOPES AS NOTED
DETAIL - UPSTREAM PLACEMENT OF DERRICK STONE
SCALE: 1"=10'-0"
DETAIL - DOWNSTREAM PLACEMENT OF DERRICK STONE
SCALE: 1"=10'-0"
1175 EXISTING CONTOURS CONTOUR INTERVAL - 1'-0"
EDGE OF EXISTING STREAM
FIGURE 5
THE GENERAL STATE AUTHORITY
HARRISBURG PENNSYLVANIA
PROJECT NO. G.S.A. - 192-1
MORAINE STATE PARK
DAM
BUTLER COUNTY PENNSYLVANIA
MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER, PENNSYLVANIA
SPILLWAY CHANNEL GRADING PLAN
DRAWING NO. 14



SECTION THRU CENTER OF SPILLWAY
SCALE 1" = 1'-0"


NOTES
1 ALL CONC TO BE 3500 PSI EXCEPT RETAINING WALLS WHICH ARE TO BE 4000 PSI
2 FOR REINFORCING DETAILS SEE DRAWING NO. 17.
3 ⓖ - DESIGNATES PAYMENT ITEM NUMBER
4 ALL EXPOSED FERROUS METAL ITEMS EXCEPT SLUICE GATE, TO BE GALVANIZED AFTER FABRICATION
SECTION B-B
SCALE ½" = 1'-0"
SECTION D-D
SCALE ½" = 1'-0"
DETAIL A
72" DIA WALL THIMBLE
NO SCALE
ELEVATION C-C
SCALE ½" = 1'-0"
SECTION A-A
SCALE ½" = 1'-0"
SECTION F-F
SCALE ½" = 1'-0"
DETAIL B
SCALE 1" = 1'-0"
FIGURE 6
THE GENERAL STATE AUTHORITY
HARRISBURG PENNSYLVANIA
PROJECT NO. G.S.A. - 192-1
MORAINE STATE PARK
DAM
BUTLER COUNTY PENNSYLVANIA
MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER, PENNSYLVANIA
OUTLET WORKS DETAILS
16


20'DS
B-7
20'US
12' U/S SPILLWAY CREST
PLAN - CUTOFF
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
TOP OF EMBANKMENT
TOP OF EMBANKMENT
GROUND SURF
STOP OF WAKEFIELD SHEET PILING
ROCK
BOTTOM OF WAKEFIELD SHEET PILING
LIMIT OF EXCAVATION
DEPTH OF GROUT HOLES
20+00
19+00
18+00
17+00
16+00
15+00
14+00
13+00
12+00
11+00
10+00
9+00
PROFILE AT CUTOFF
SCALE: 1"=10' VER. & 1"=50' HOR.
1180
1170
1160
LIMIT OF EXCAVATION
2 FEET OF ROLLED IMPERVIOUS @ (PLATFORM FOR WAKEFIELD DRIVING)
2 TO 3 FEET OF ROLLED IMPERVIOUS
LIMIT OF EXCAVATION
ROCK
ROCK
DEPTH OF GROUT HOLES @ 4'
20+00
19+00
18+00
17+00
16+00
15+00
14+00
13+00
12+00
11+00
10+00
9+00
PROFILE AT CUTOFF - GROUT CURTAIN
SCALE: 1"=10' VER. & 1"=50' HOR.



10-68-19
FILE NUMBER

RECEIVED IN THE OFFICE OF THE WATER & POWER RESOURCES BOARD, DEPARTMENT OF FORESTS & WATERS ON THE 16th of [illegible] A.D. 1965

REC'D ______ FOR ______
GSE REPORT NO. ______

FIGURE 7

NOTES
1. (0) DESIGNATES PAYMENT ITEM NUMBER

CHECKED BY DEPT. OF FORESTS & WATERS

ENGINEER
3/4/65
DATE

SYMBOL | REVISIONS

APPROVED
CHIEF - DIVISION OF FLOOD CONTROL

APPROVED
ASSISTANT DIRECTOR OF ENGINEERING

CHECKED BY THE GENERAL STATE AUTHORITY

STRUC. ELECT. MISC.

THE GENERAL STATE AUTHORITY
HARRISBURG PENNSYLVANIA

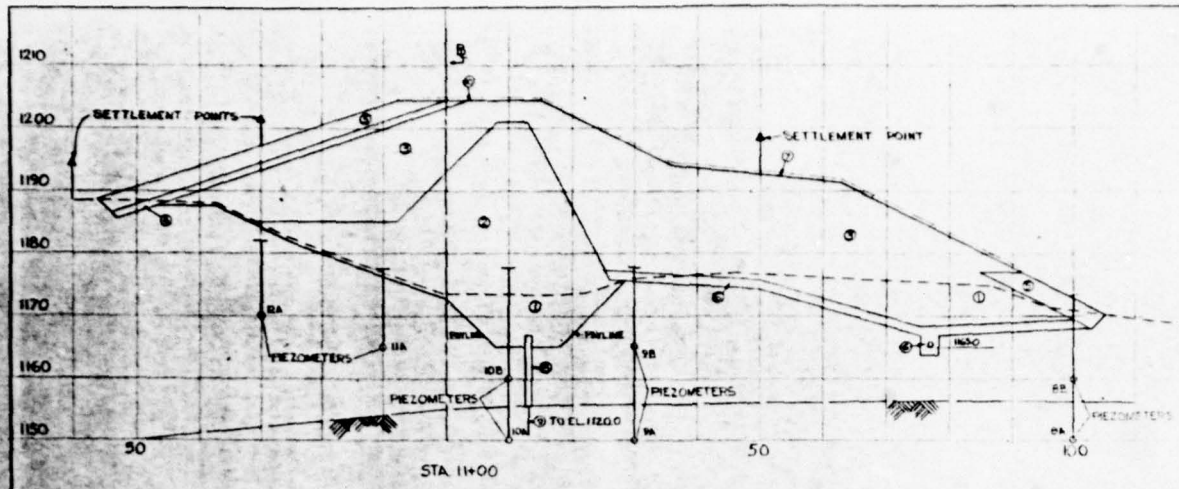
PROJECT NO. G.S.A. – 192-1

MORAINE STATE PARK
DAM
BUTLER COUNTY PENNSYLVANIA

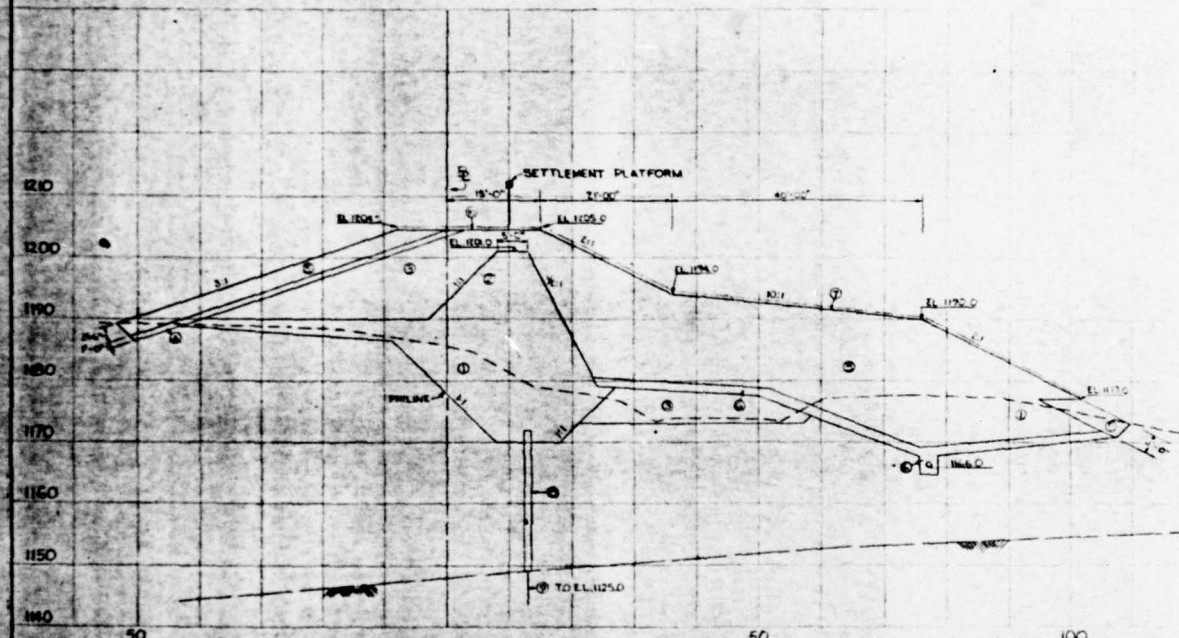
MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER, PENNSYLVANIA

WAKEFIELD & GROUT PROFILE

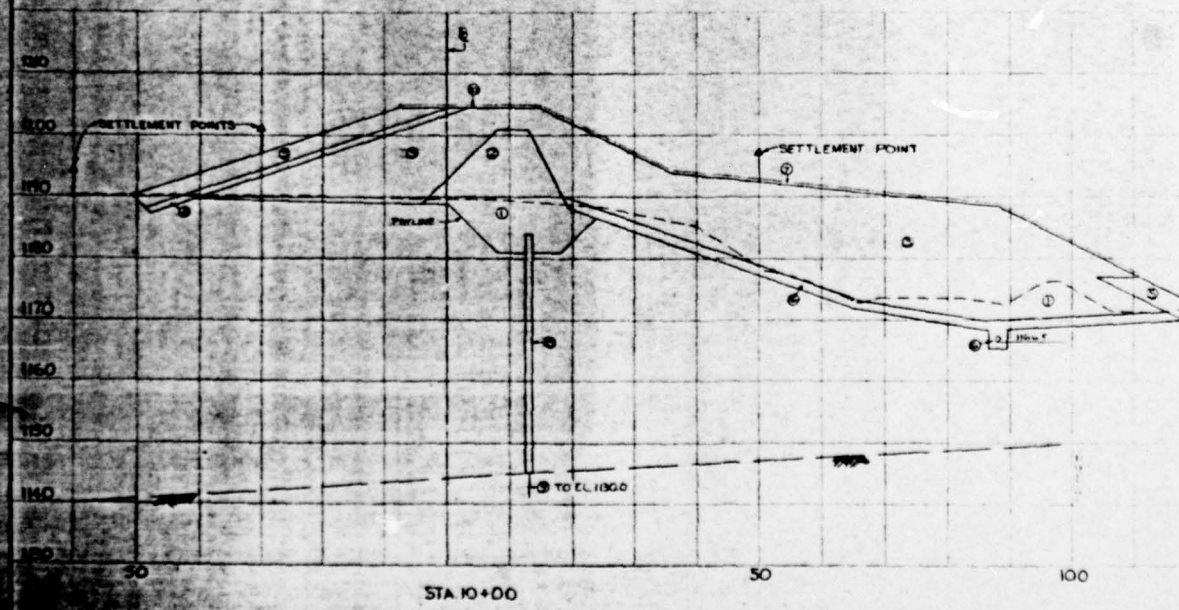
DRAWN BY	CHECKED BY	DATE	SCALE	DRAWING NO.
		3/4/65	AS SHOWN	19 of 42



STA. 11+00



STA. 10+50



STA. 10+00

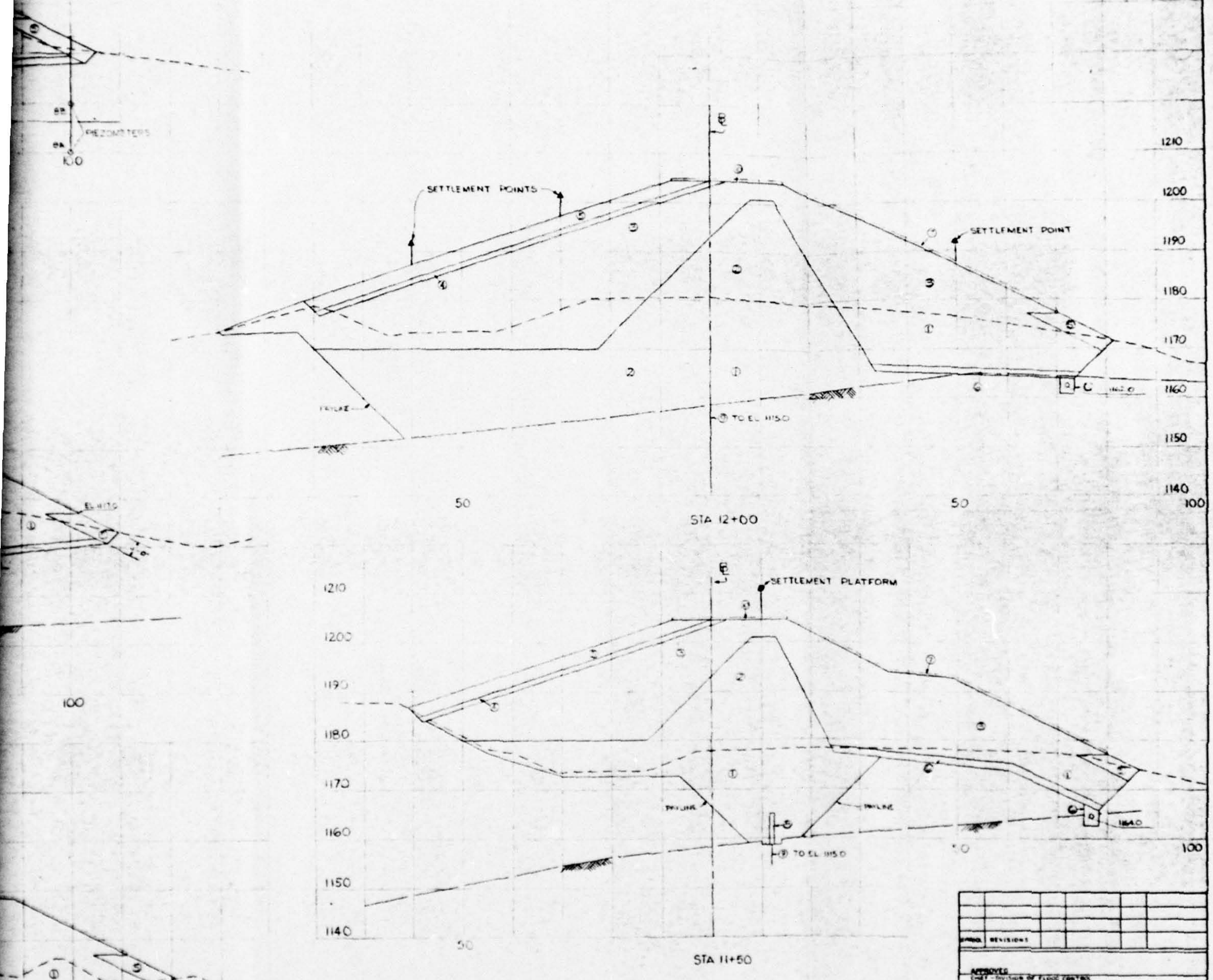


FIGURE 8

NOTES

1. ⓪ Designates Payment Item Number
2. Code: ① Excavation ⑥ ⑦
   ② Impervious Core ⑧
   ③ Pervious Shell ⑨
   ④ Filter Blanket ⑫
   ⑤ Rip Rap ⑫
   ⑥ Blanket Drain and Trench ⑧
   ⑦ Topsoil ⑲
   ⑧ Wakefield Sheet Piling ④
   ⑨ Grouting ⑬ ⑭ ⑮ ⑯ ⑰
   ⑩ Selected Material ...

CHECKED BY DEPT. OF FORESTS & WATERS

ENGINEER

DATE

SYMBOL | REVISIONS

APPROVED
CHIEF - DIVISION OF FLOOD CONTROL

APPROVED
ASSISTANT DIRECTOR OF ENGINEERING

CHECKED BY THE GENERAL STATE AUTHORITY
STRUC. ELECT. MISC.

THE GENERAL STATE AUTHORITY
HARRISBURG PENNSYLVANIA

PROJECT NO. G.S.A. – 192-1

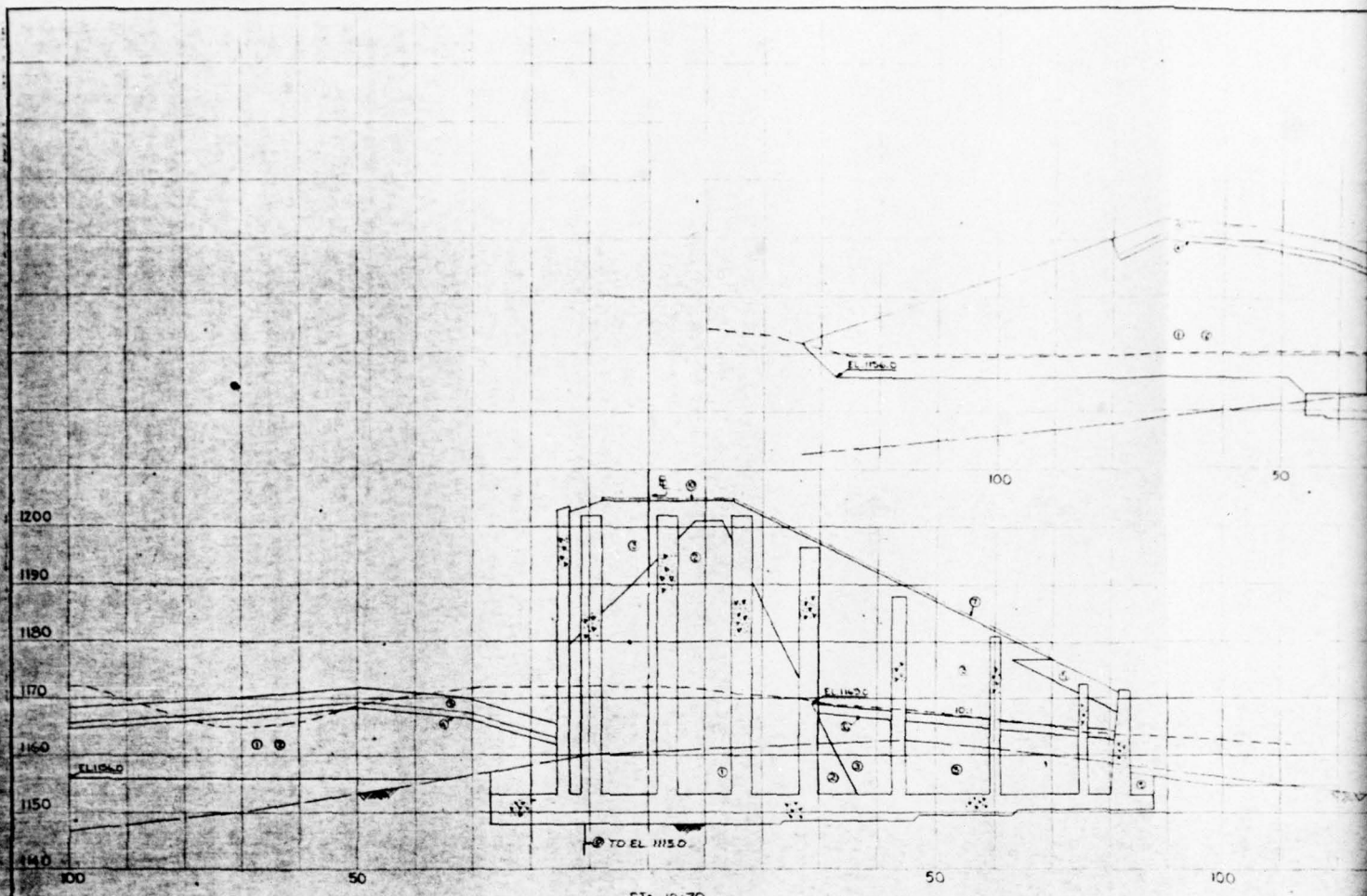
MORAINE STATE PARK
DAM
BUTLER COUNTY PENNSYLVANIA

MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER, PENNSYLVANIA

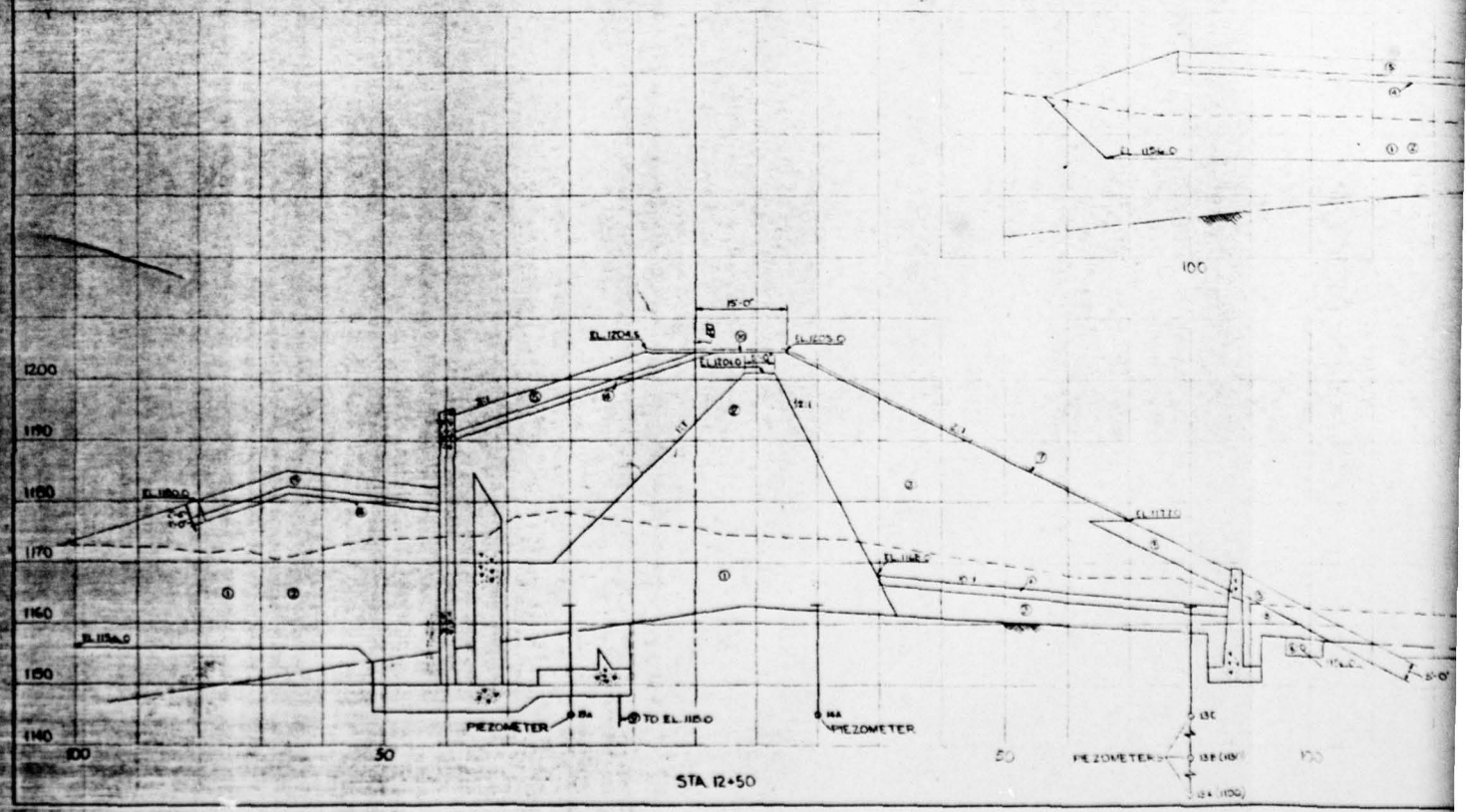
CROSS SECTIONS – 10+00 TO 12+00

DRAWN BY	CHECKED BY	DATE	SCALE	DRAWING NO.
		3/4/65	1"=10'	23 of 42

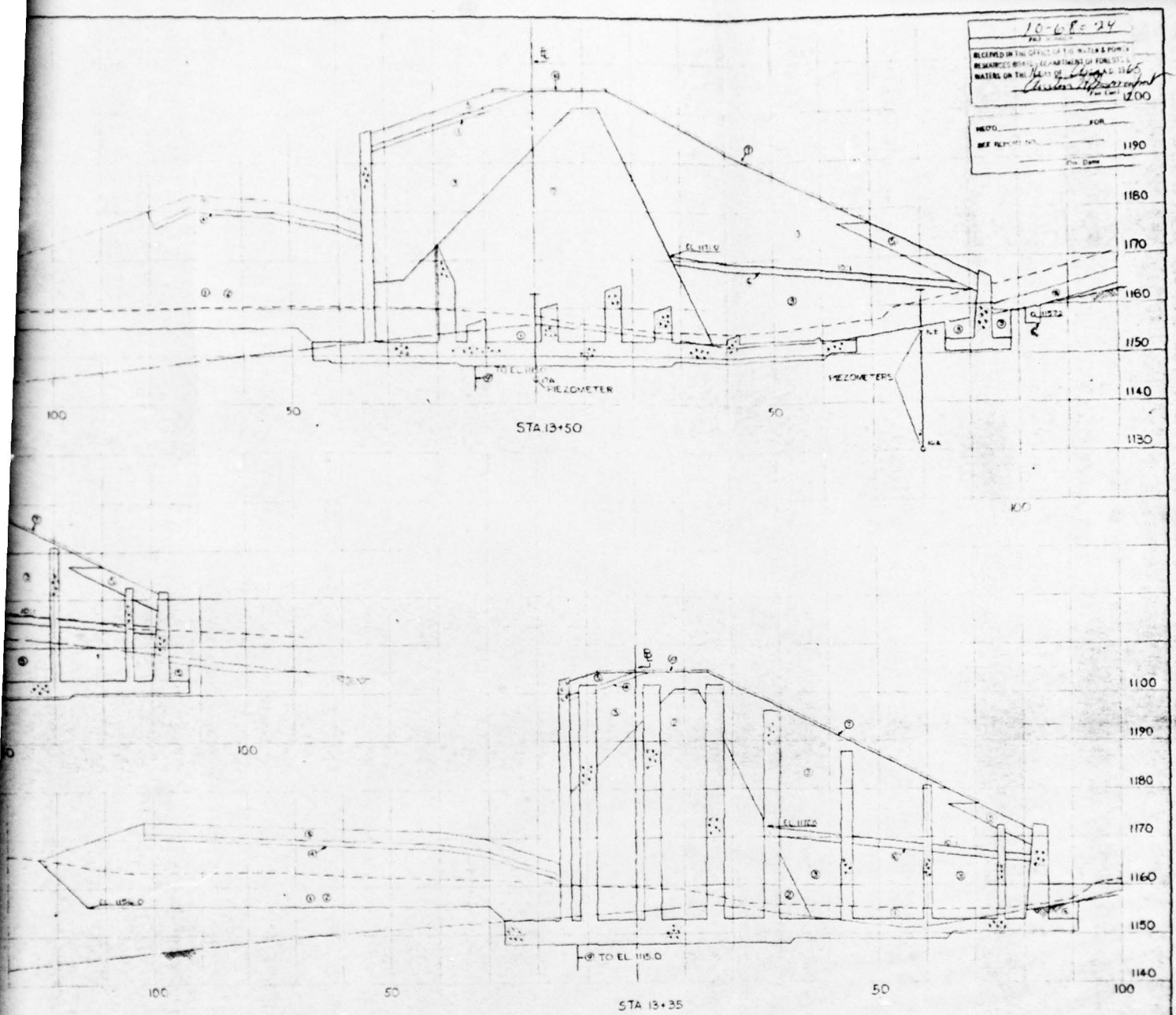
9

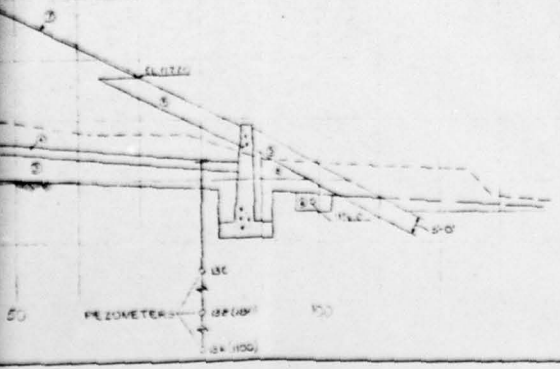


STA 12+70



STA 12+50





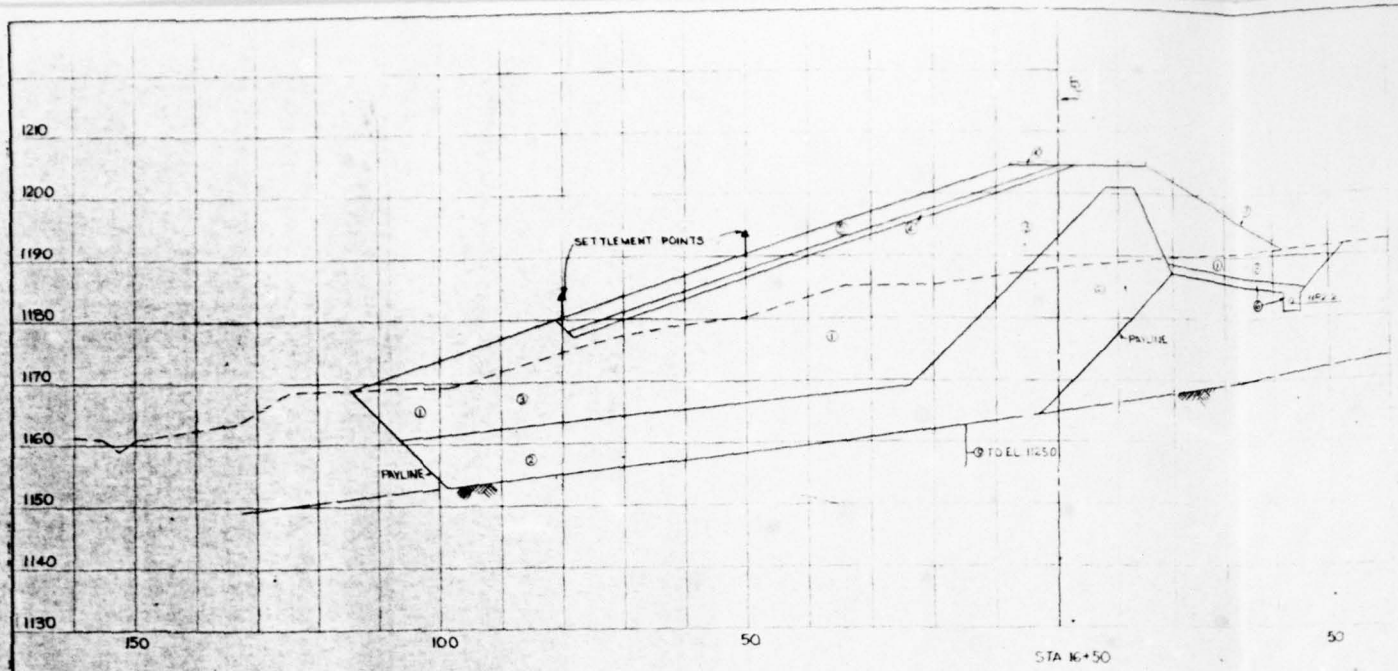
NOTES

1. ⑨ DESIGNATES PAYMENT ITEM NUMBER
2. CODE: ① EXCAVATION ⑥ ⑦

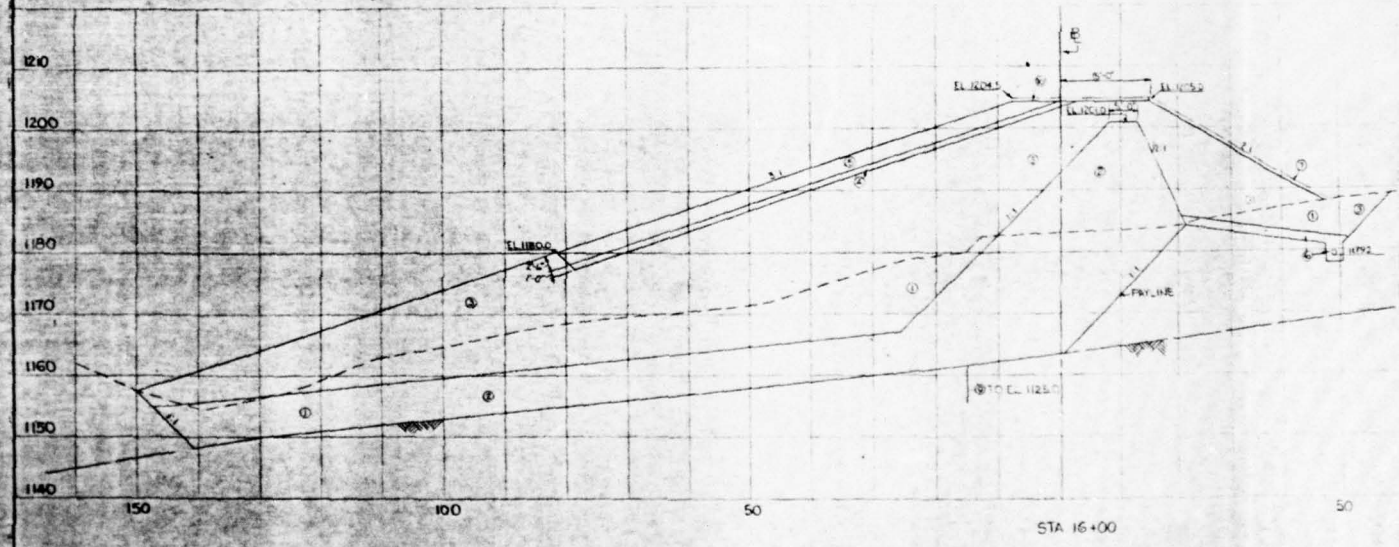
FIGURE 9

	THE GENERAL STATE AUTHORITY HARRISBURG PENNSYLVANIA
	PROJECT NO. G.S.A. – 192-1
	MORAINE STATE PARK DAM BUTLER COUNTY PENNSYLVANIA
	MICHAEL BAKER, JR., INC. CONSULTING ENGINEERS ROCHESTER, PENNSYLVANIA
	CROSS SECTIONS – 12+50 TO 13+80
	24 of 42

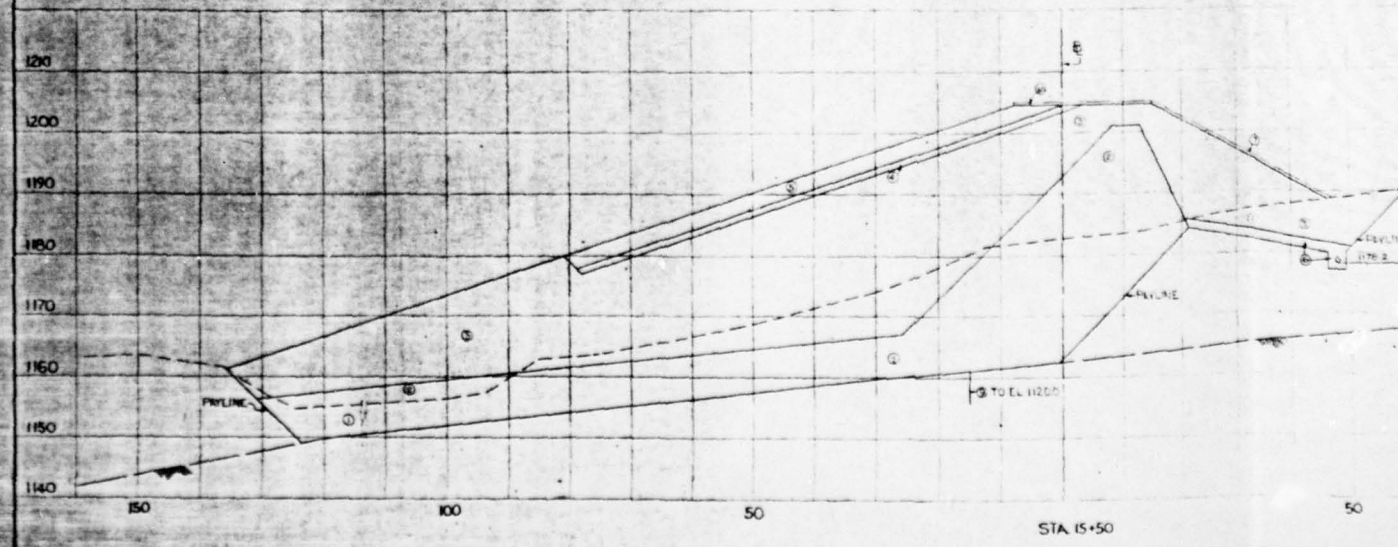
2



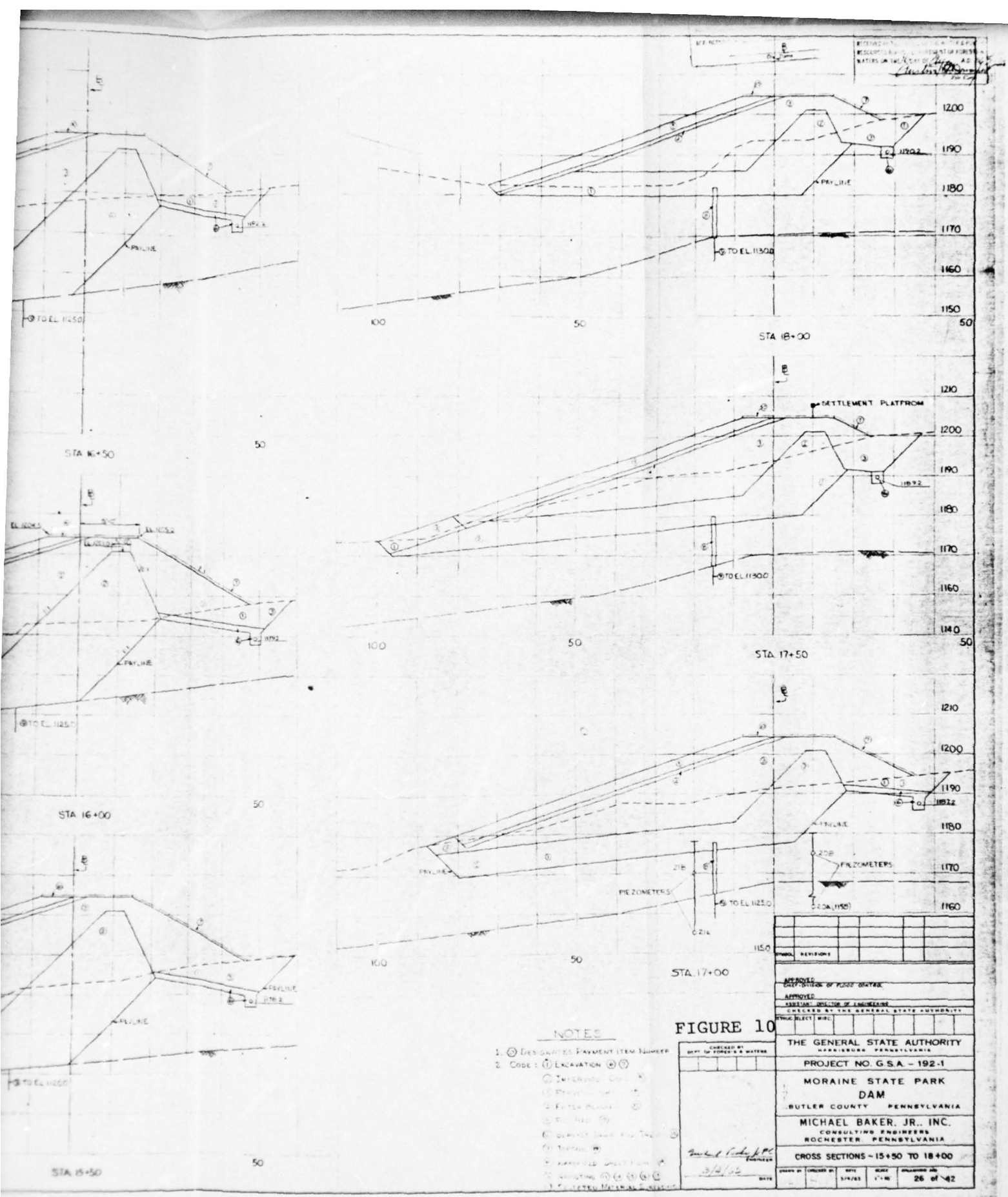
STA 16+50



STA 16+00



STA 15+50



NOTES

1. ⑤ DESIGNATES PAYMENT ITEM NUMBER
2. CODE : ① EXCAVATION ⑥ ⑦

FIGURE 10

APPROVED: CHIEF DIVISION OF FLOOD CONTROL	
APPROVED: ASSISTANT DIRECTOR OF ENGINEERING	
CHECKED BY THE GENERAL STATE AUTHORITY	
SYMBOL / REVISIONS	
THE GENERAL STATE AUTHORITY HARRISBURG, PENNSYLVANIA	
PROJECT NO. G.S.A. - 192-1	
MORAINE STATE PARK DAM BUTLER COUNTY PENNSYLVANIA	
MICHAEL BAKER, JR., INC. CONSULTING ENGINEERS ROCHESTER, PENNSYLVANIA	
CROSS SECTIONS - 15+50 TO 18+00	
DRAWN BY / CHECKED BY / DATE 3/9/65 / SCALE 1"=50 / DRAWING NO. 26 of 42	

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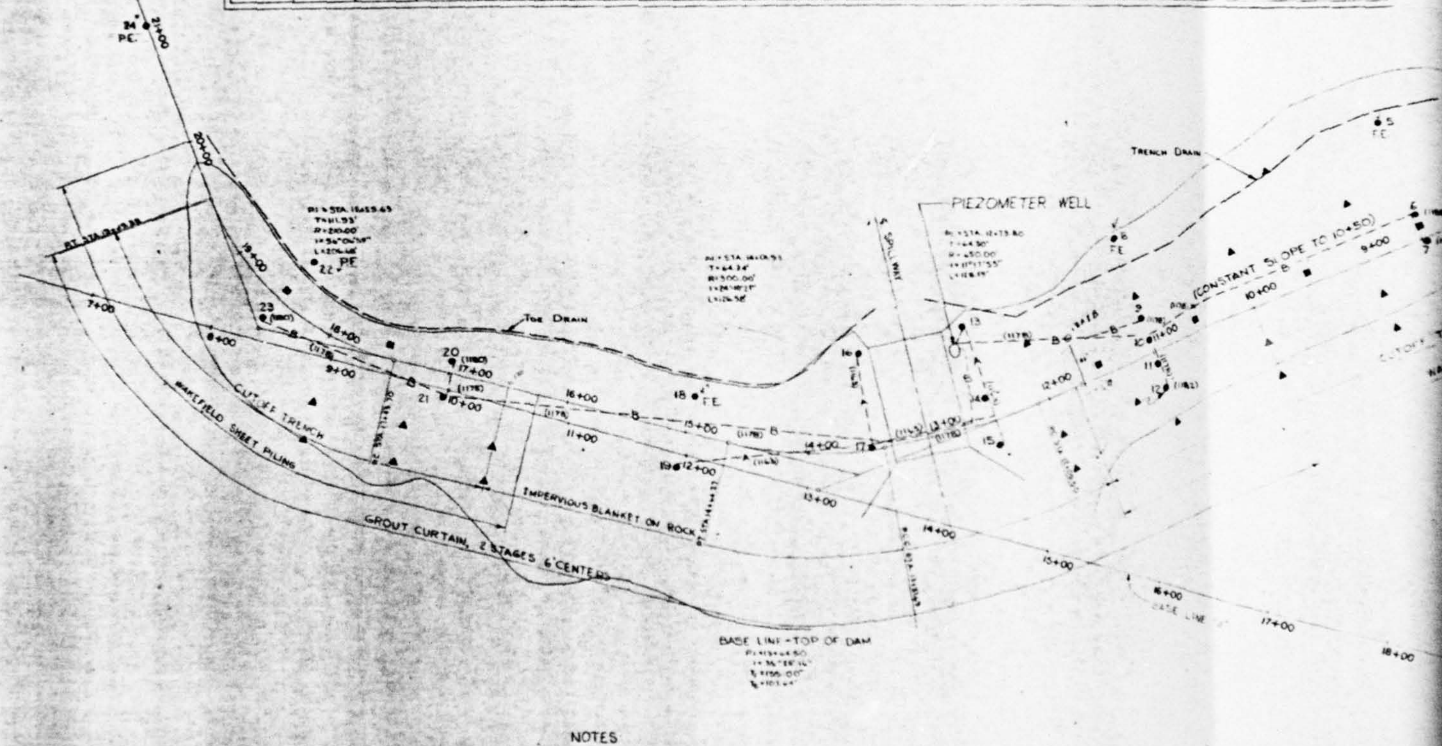
ENGINEER

3/9/65
DATE

LOCATION OF PIEZOMETER TIPS

STATION	TIP NO.	℄ OFFSET	ELEVATION	* PURPOSE X	Y	Z	DWG	REMARKS
0+00	1 A	℄	1150		✓		21	
	1 B	℄	1170		✓		21	
	2 A	300' D.S.	1150		✓		21	
	2 B	300' D.S.	1170		✓		21	
4+50	3 A	250' D.S.	1150		✓		21	
	3 B	250' D.S.	1170		✓		21	
	4 A	35' D.S.	1150		✓		21	
	4 B	35' D.S.	1170		✓		21	
	4 C	35' D.S.	1185		✓		21	
8+50	5 A	100' D.S.	1150		✓		22	
	5 B	100' D.S.	1170		✓	✓	22	
	6 A	20' D.S.	1175	✓	✓		22	
	7 A	5' U.S.	1150		✓		22	
	7 B	5' U.S.	1175	✓	✓		22	
11+00	8 A	100' D.S.	1150			✓	23	
	8 B	100' D.S.	1160	✓	✓		23	
	9 A	30' D.S.	1150			✓	23	
	9 B	30' D.S.	1165	✓	✓		23	
	10 A	10' D.S.	1150			✓	23	
	10 B	10' D.S.	1160	✓	✓		23	
	11 A	10' U.S.	1165	✓	✓		23	
	12 A	30' U.S.	1170	✓	✓		23	
12+50	13 A	80' D.S.	1100			✓	24	
	13 B	80' D.S.	1130			✓	24	
	13 C	80' D.S.	1145			✓	24	
	14 A	20' D.S.	1145			✓	24	
	15 A	20' U.S.	1145			✓	24	
13+50	16 A	80' D.S.	1130			✓	24	
	16 B	80' D.S.	1145			✓	24	
	17 A	℄	1145			✓	24	
15+00	18 A	30' D.S.	1155			✓	25	
	18 B	30' D.S.	1175	✓			25	
	19 A	30' U.S.	1150			✓	25	
17+00	20 A	10' D.S.	1155			✓	26	
	20 B	10' D.S.	1175	✓	✓		26	
	21 A	20' U.S.	1155			✓	26	
	21 B	20' U.S.	1170	✓	✓		26	
18+50	22 A	40' D.S.	1165			✓	27	
	22 B	40' D.S.	1175		✓		27	
	23 A	20' U.S.	1162			✓	27	
	23 B	20' U.S.	1170	✓	✓		27	
21+00	24 A	℄	1160			✓	27	
	24 B	℄	1180		✓		27	



—B- - - - 10 ● 11 ● 12 ● (1182) Indicates Location Of Trench And Piezometer Tips

■ Settlement Platform
▲ Settlement Point

P.E. = Install Piezometer Prior To Excavation
F.E. = Install Piezometer After Foundation Is Exposed. Work Platform Of At Least 5 Feet Of Compacted Fill Should Be Placed Prior To Drilling. Piezometer To Be Carried To Top Of Embankment Through A Pipe.

NOTES

When Embankment Reaches Elevation 1165 Series "A" Trench System Shall Be Cut To The Elevation Indicated Below, And Piezometer Tips 13 To 17 And 19 Are Installed.

When Embankment Reaches Elevation 1180 Series "B" Trench System Shall Be Cut To The Elevation Indicated Below, And Piezometer Tips 6, 7, 9 To 12, 20, 21, And 23 Are Installed.

Piezometer 1 To 5, 6, 18, 22, And 24 Shall Be The Casagrande Porous-Tube Type.

TIPS

OFFSET	ELEVATION	* PURPOSE X	Y	Z	DWG	REMARKS
0' D.S.	1130			✓	24	
0' D.S.	1145			✓	24	
℄	1145			✓	24	
0' D.S.	1155			✓	25	
0' D.S.	1175	✓			25	
0' U.S.	1150			✓	25	
0' D.S.	1155			✓	26	
0' D.S.	1175	✓	✓		26	
0' U.S.	1155			✓	26	
0' U.S.	1170	✓	✓		26	
40' D.S.	1165			✓	27	
40' D.S.	1175		✓		27	
20' U.S.	1162			✓	27	
20' U.S.	1170	✓	✓		27	
℄	1160			✓	27	
℄	1180		✓		27	

* DESCRIPTION OF PURPOSES
X - TO MONITOR STABILITY OF FOUNDATION DURING CONSTRUCTION
Y - TO MONITOR STABILITY OF ABUTMENTS AFTER RESERVOIR FILLING AND/OR EFFECTIVENESS OF WAKEFIELD SHEET PILING AND UPSTREAM BLANKET.
Z - TO MONITOR UPLIFT PRESSURES IN BEDROCK AND/OR EFFECTIVENESS OF GROUTING

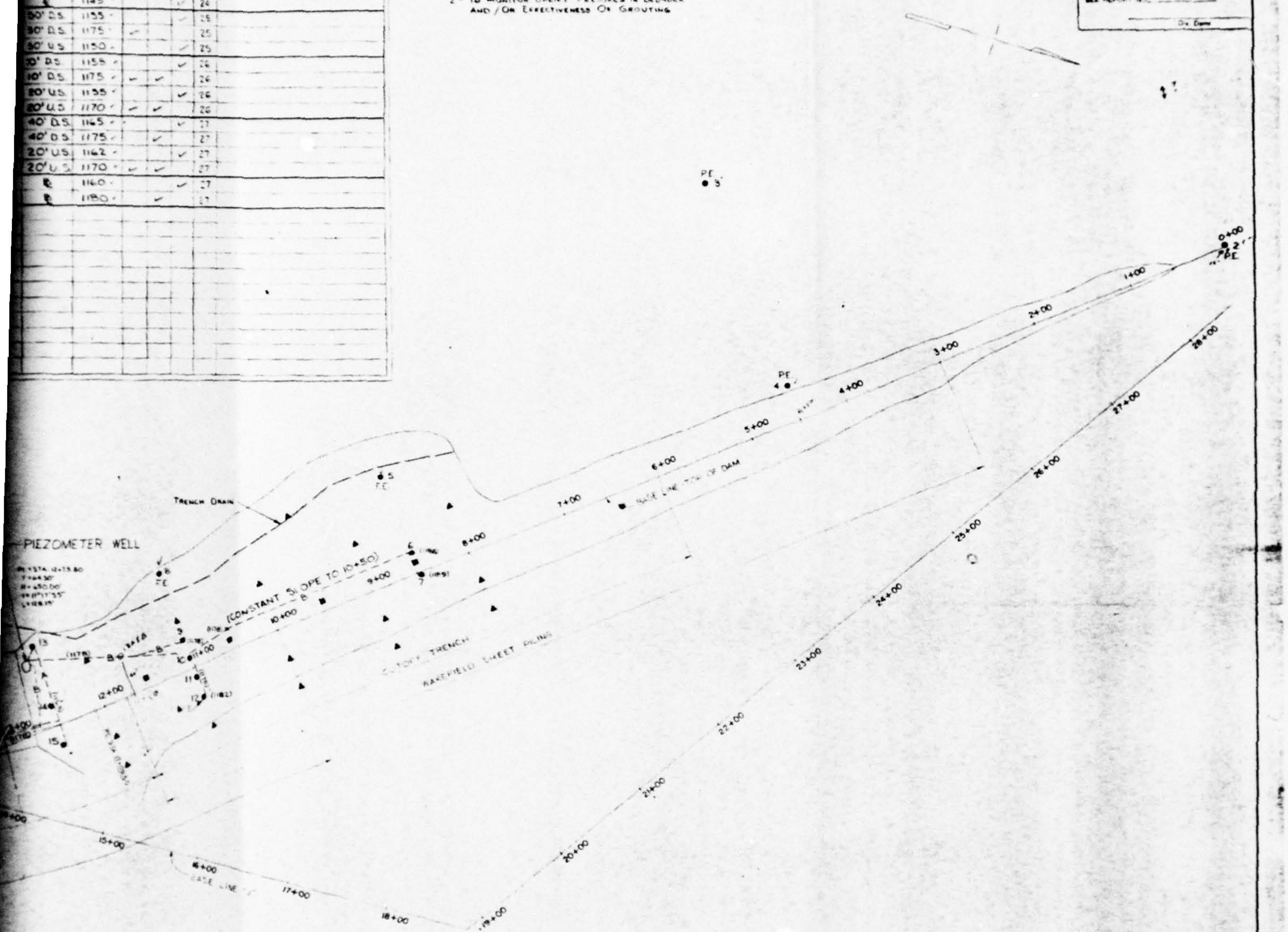


FIGURE 11

SYMBOL	REVISIONS				

APPROVED
CHIEF-DIVISION OF FLOOD CONTROL

APPROVED
ASSISTANT DIRECTOR OF ENGINEERING

CHECKED BY THE GENERAL STATE AUTHORITY
STRUC. ELECT. MISC.

CHECKED BY
DEPT. OF FORESTS & WATERS

THE GENERAL STATE AUTHORITY
HARRISBURG, PENNSYLVANIA

PROJECT NO. G.S.A. - 192-1

MORAINE STATE PARK
PROPOSED DAM
BUTLER COUNTY PENNSYLVANIA

MICHAEL BAKER, JR., INC.
CONSULTING ENGINEERS
ROCHESTER, PENNSYLVANIA

ENGINEER
PLAN OF CONTROL INSTRUMENTATION, CUTOFF FEATURES AND TRENCH DRAINS

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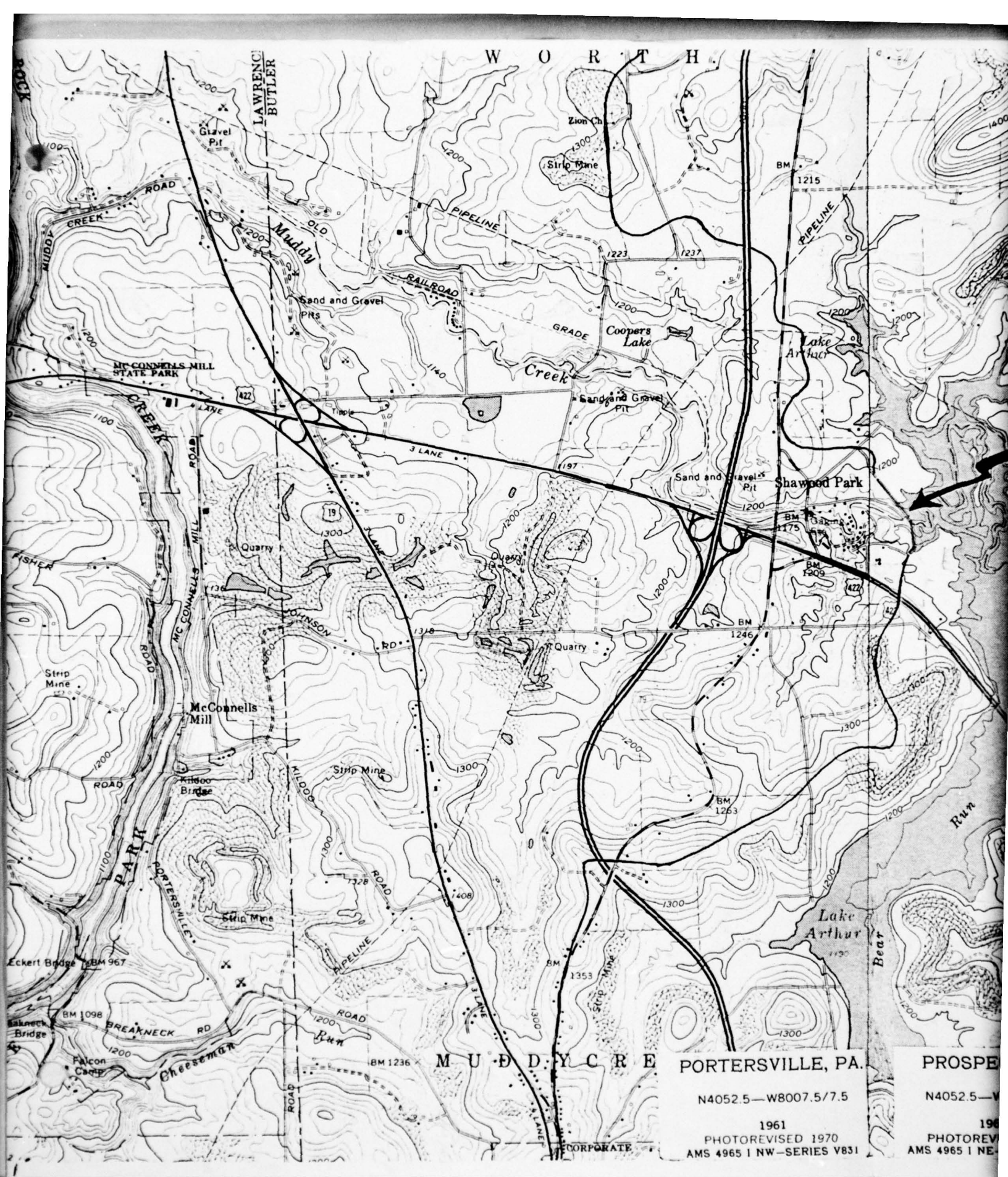
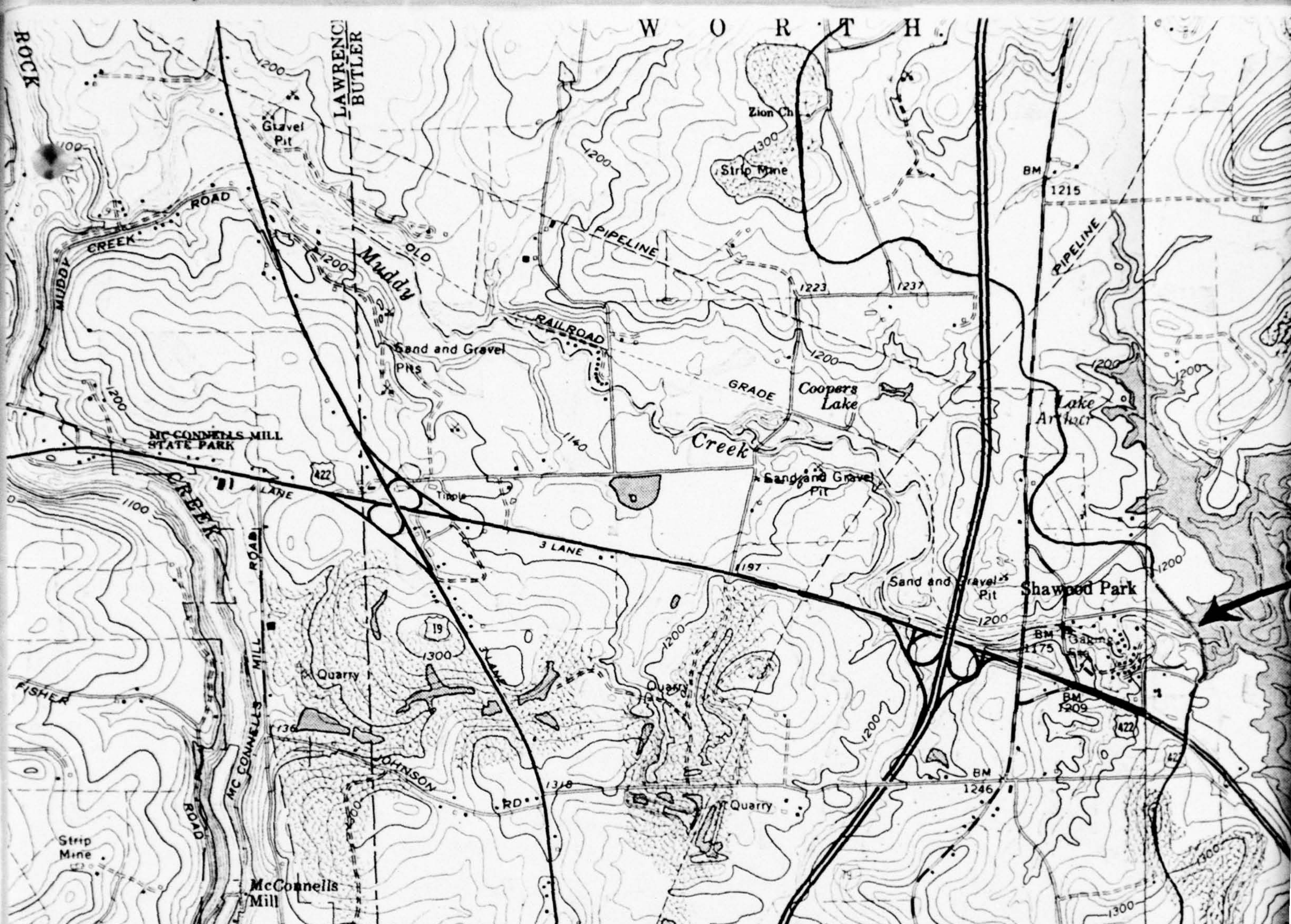
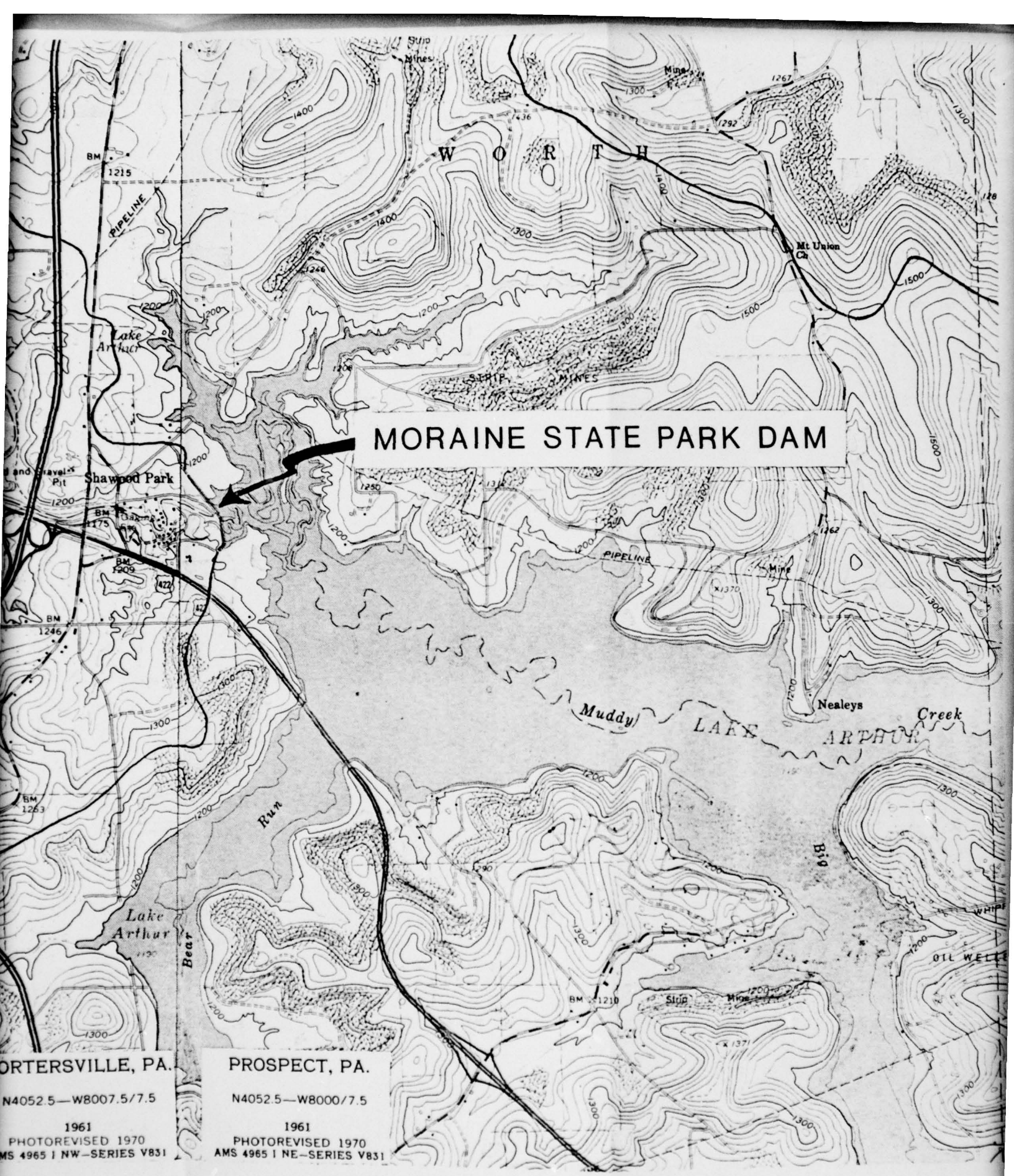
FEW	RJD			29 of 42

APPENDIX G

REGIONAL VICINITY MAP


W O R T H
LAWRENCE
BUTLER
Gravel Pit
Zion Ch
Strip Mine
BM 1215
PIPELINE
MUDDY CREEK ROAD
OLD
Muddy
RAILROAD
Sand and Gravel Pits
GRADE
Coopers Lake
Lake Arthur
Creek
McCONNELLS MILL STATE PARK
422
Sand and Gravel Pit
3 LANE
Shawood Park
Quarry
19
FISHER
McCONNELLS MILL ROAD
JOHNSON RD
Strip Mine
McConnells Mill
Kildoo Bridge
KILDOO ROAD
PARK
PORTERSVILLE ROAD
Eckert Bridge
BM 967
BM 1098
BREAKNECK RD
Breakneck Bridge
Falcon Camp
Cheeseman Run
BM 1236
M U D D Y C R E
Bear Run
Lake Arthur
PORTERSVILLE, PA.
N4052.5—W8007.5/7.5
1961
PHOTOREVISED 1970
AMS 4965 I NW—SERIES V831
PROSPE
N4052.5—W
19
PHOTOREV
AMS 4965 I NE-
CORPORATE


PORTERSVILLE, PA.
N4052.5—W8007.5/7.5
1961
PHOTOREVISED 1970
AMS 4965 I NW—SERIES V831
W O R T H
M U D D Y C R E
ROCK
LAWRENCE
BUTLER
Gravel Pit
Zion Ch
Strip Mine
MUDDY CREEK ROAD
Muddy
OLD RAILROAD GRADE
PIPELINE
Sand and Gravel Pits
Coopers Lake
Creek
Lake Arthur
McCONNELLS MILL STATE PARK
CREEK
Tipple
3 LANE
Sand and Gravel Pit
Shawood Park
Quarry
JOHNSON RD
FISHER
MC CONNELLS MILL ROAD
Strip Mine
McConnells Mill
ROAD
Kildoo Bridge
KILDOO ROAD
PARK
PORTERSVILLE
Eckert Bridge
BM 967
BM 1098
Breakneck Bridge
BREAKNECK RD
Falcon Camp
Cheeseman Run
BM 1236
CORPORATE
Bear
BM 1215
BM 1175
BM 1209
BM 1246
BM 1263
BM 1353
422
19



ORTERSVILLE, PA.

N4052.5—W8007.5/7.5

1961

PHOTOREVISED 1970

AMS 4965 I NW—SERIES V831

PROSPECT, PA.

N4052.5—W8000/7.5

1961

PHOTOREVISED 1970

AMS 4965 I NE—SERIES V831